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A

SVIC NOTES

BALANCING TERMINOLOGY

Isn't it about time that the U.S. balancing community switched to SI units? How can it be that some groups are still recommending that the terms "mass" and "weight" be used interchangeably? In this note, I challenge the U.S. balancing community to bring itself into alignment with accepted international usage in balancing terminology. I will also suggest possible courses of action to bring about this overdue change.

In Europe and the UK, virtually everyone uses the terms rotor mass, test mass, mass unbalance, etc. This is the best way to think of unbalance. It's the mass inhomogeneities of a rotor which cause it to be unbalanced, not its weight inhomogeneities. If you spin a rotor at some fixed rpm on the surface of the earth or on the moon it will have the same unbalanced response. Both the unbalanced weight and the rotor weight are different on the moon and the earth. Their masses, however, are the same.

The balancing technical community is not large and policy is influenced by a few key individuals. Unless this leadership decides to bring about a change, it will not happen.

There are several possible ways to bring about the needed changes, some of which are already being used. The professional societies have already taken steps to require that SI units are the primary units to be used in their publications. They should carefully monitor rotor and balancing papers to ensure their requirements are met. The U.S. Government should also make sure that the appropriate balancing terminology is used in any government publication.

Finally, the user community must be educated. There should be no misunderstanding about the basics, such as Newton's First Law (F = ma) or the difference between mass and weight. The manufacturers of both rotors and rotor balancing machines should play key roles in this education process. Educational organizations could contribute also, by working the appropriate material into short courses.

The changes are needed and long overdue. The ranking members of the U.S. balancing community are urged to bring them about. I hope this short note will encourage them to do so.

J.G.S.

EDITORS RATTLE SPACE

MATHEMATICS IN ENGINEERING EDUCATION

For some reason mathematics is being overemphasized in engineering education. The fate of the student hinges on his ability to solve differential equations rather than on his design capability. And, in some cases, the graduating engineer knows little about the physical world and even less about the techniques needed to evaluate it. I challenge readers of this column to find a current textbook on mechanical vibration that is not burdened with mathematics. The emphasis on mathematics has increased to the point that more space is used to manipulate equations than to describe why and how equipment and structures vibrate. In my view mathematics should supplement physical descriptions – not replace them. A true description of the physics of vibration requires little mathematics. Vibration problems can be solved both mathematically and experimentally. Why is it then that most of the world of education is preoccupied with teaching mathematical simulation when many physical systems are difficult to model? Often data are not even available for the models.

My opinion is that educators have been trapped by the beauty and apparent exactness of mathematics. Deterministic solutions look good on paper, and, if instructors haven't been exposed to other approaches, such solutions are easy to use and to elaborate. The result has been a trend in which basic textbooks on mechanical vibration have become more mathematically oriented in the past 20 years.

The digital computer has also enhanced the role of mathematics. It motivated the development of numerical methods and has been a powerful tool in solving complicated problems – far beyond the point of diminishing return. It is difficult to visualize and sometimes impossible to evaluate results obtained from pages of computer output for huge multimass models.

Finally, students are often not even exposed to test equipment at many universities because it simply isn't there. Money is spent on huge computers but has been scarce in the labs. Thus, students never have the opportunity to evaluate physical systems experimentally. Unfortunately, without the experimental approach physical descriptions of phenomena are neglected.

I believe that engineering would be best served if educators took stock of what is being done in industry and then evaluated what they are teaching. It seems to me that a balanced curriculum with less mathematics and greater emphasis on physical descriptions would produce better equipped students and narrow the gap between industry and education. I welcome rebuttals from those who do not share my views.

R.L.E.

SOUND ATTENUATION OVER GROUND COVER III

K. Attenborough*

Abstract. This review of recent developments in predicting noise from surface transport sources takes into account ground effects and the presence of purpose-built noise barriers. Mechanisms of sound attenuation in forests are outlined. Developments in the measurement of acoustic properties of the ground are discussed. Finally, useful directions for further work are proposed.

Earlier reviews [1, 2] have mentioned that methods for predicting highway noise and aircraft noise over plane-absorbing ground and for deriving test procedures and conditions for regulating noise emission from individual vehicles require the analysis of sound attenuation over ground cover. It is also necessary to incorporate ground effects into predictions of highway noise attenuation by purposely built barriers. Furthermore there is military interest in predicting the sound field below the ground that results from sound sources above and close to the ground surface. The latter is associated with the design and location of subsurface sensor arrays [3].

This review has to do with recent advances in theoretical analysis and the measurement of acoustic properties of the ground. Particular attention is paid to predicting sound propagation through forests and to the effects of discontinuities between plane surfaces of differing acoustical properties. Although such effects of atmospheric conditions as turbulence, wind, and temperature gradients are important to propagation of sound near to the ground, they are not discussed here beyond citations of recent reviews [4,5].

THEORY

When the ground surface is assumed to be locally reacting, it can be shown that all of the solutions for the total field velocity potential and based upon contour integration, using the method of steepest descents [1, 2], can be written in the following form [6]

$$\phi_{tot} = \frac{e^{ikR_1}}{ikR_1} + R(\theta_0)\frac{e^{ikR_2}}{ikR_2} + [1 - R(\theta_0)]\,F(w)\,\frac{e^{ikR_2}}{ikR_2} \quad (1)$$

R_1 and R_2 represent the distance from the point source and its mirror image respectively, θ_0 is the specular angle of reflection, and $R(\theta_0)$ is the plane wave reflection coefficient given by

$$R(\theta_0) = \frac{\cos\theta_0 - \beta}{\cos\theta_0 + \beta} \quad (2)$$

β is the specific normal surface admittance of the ground, and w, sometimes referred to as a numerical distance, is given by

$$w^2 = \tfrac{1}{2}\, ikR_2\, (\beta + \cos\theta_0)^2 \quad (3)$$

The time dependence $\exp(-i\omega t)$ is understood; $\mathrm{Im}(\beta) < 0$ represents a springlike reactance.

In addition to $\theta_0 \simeq \frac{\pi}{2}$, equation (1) requires that $kR_2 > 1$ and $|\beta| < 1$. These are not severe restrictions for most noise predictions. Indeed when kR_2 is sufficiently large that $|w| > 1$,

$$F(w) = 2i\pi^{\frac{1}{2}} w e^{-w^2} H(-\mathrm{Im}(w)) - \frac{1}{2w^2} - \frac{1\cdot3}{(2w^2)^2} - \frac{1\cdot3\cdot5}{(2w^2)^3} \quad (4)$$

to $O(w^{-6})$. Im(w) represents the imaginary part of w; H( ) is the Heaviside step function, such that

$$H(-\mathrm{Im}(w)) = 1 \qquad \mathrm{Im}(w) < 0$$
$$= 0 \qquad \text{else}$$

The first term of F can be interpreted as a surface wave because it has relevant characteristics [7] and, at grazing incidence, contributes to the total received field whenever the magnitude of the imaginary part

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of β exceeds the real part. The consequence of the existence of a contribution from the surface wave term is a reduction in the excess attenuation (over geometric spreading) of noise from a source near to ground with nonzero admittance. It follows that the excess attenuation of sound over a plane boundary with an admittance vs. frequency characteristic typical of that of a thin rigidly backed layer is small. On the other hand, certain measured and deduced admittance vs. frequency characteristics of sand and stubble are predicted to give unusually large excess attenuations according to the above theory [8].

The local reaction assumption requires that the acoustic behavior of the ground is represented adequately by that of a modified fluid with complex index of refraction n such that $\sin^2\theta_0/|n|^2 \ll 1$. This condition implies that the speed of sound in the ground is considerably less than in air. This is more likely to be true at low frequencies than at high ones [9]. An alternative assumption is that the ground can be modeled acoustically as a modified fluid half-space exhibiting external reaction. For this assumption two solutions are available [6, 10]; one of them [6] has the same form as equation (1). These assumptions have not yet been tested numerically. They require knowledge of the bulk propagation constant for dilatational waves within the fluid medium.

Two solutions are also available for the field due to a point sound source above a plane ground that can be modeled as a rigidly-backed layer [10, 11]. The solution of Thomasson [11] is expressed in terms of a correction to the solution for a locally-reacting boundary. Again these solutions have not yet been tested numerically. One method of dealing with the presence of an impedance discontinuity in a plane boundary is to adapt the theory of diffraction by an impedance-covered barrier by putting the wedge angle equal to 90° [12]. The impedances on either side of the barrier can be assigned different values. Alternative and more rigorous approaches utilize integral transform techniques [13, 14]. In one approach [13] both of the surfaces either side of the impedance boundary are supposed to be locally reacting.

It has been common to refer to the excess attenuation of purposely built noise barriers; i.e., the effect of the barrier with respect to the free-field condition. However, the barrier is built on the ground, and, if the surrounding terrain is acoustically-soft, the problem arises of determining the insertion loss resulting from its construction. If the third term in equation (1) is neglected, the presence of the ground and barrier together can be dealt with by the image concept [12]. However, other more rigorous solutions are available [15, 16, 31]. There has thus far been no numerical comparison of these solutions.

ATTENUATION IN FORESTS

Shelter belts of trees are traditionally regarded by highway engineers and planners as having an insignificant effect on the propagation of road traffic noise. Nevertheless, recent measurements indicate that the insertion loss of tree belts only 25 meters wide can be comparable with that achieved by purposely built barriers for both railway noise and highway noise [17-19]. Various mechanisms of sound dissipation have been suggested: multiple scattering by tree boles and branches [20], thermo-viscous absorption at foliage surfaces [21-23], absorption by mechanical resonances of branches and foliage [20, 22], and excess attenuation due to reflection with phase change at the forest floor [8, 25]. Although no attempt has yet been made to incorporate all of these effects into a single mathematical model for propagation within forests, it would seem that the ground effect is likely to dominate at low frequencies and thermo-viscous effects in foliage at high frequencies.

For certain impedance vs. frequency characteristics typical of forest floors it is predicted that the excess attenuation at intermediate frequencies will be less than that which would result from grazing-incidence propagation over open plane grassland [8]. A phenomenological model of the forest as a multiple-layer medium is also available [26].

ACOUSTIC PROPERTIES OF GROUND

The number of in situ measurements of the acoustic properties of the various types of outdoor ground cover remains fairly small. The impedance tube techniques represent modifications of the standard laboratory method used to obtain the surface impedance of sound absorbents. The modifications enable the standing wave tube to be used vertically

and to be driven into the ground [4, 27, 28]. Normal incidence information is adequate so long as the ground can be modeled as locally reacting.

Free-field techniques rely either upon mounting a source sufficiently far from the ground so that wavefronts can be modeled as plane or upon arranging the geometry of the measurements such that the total field at the receiver is represented by only the first two terms in equation (1) [28]. Other methods that have been used include grazing-incidence and pulse techniques [29]. Unfortunately, interference techniques are sensitive to the assumed location of the ground surface and grazing-incidence techniques are sensitive to the assumed model for the acoustic behavior of the ground. Except for certain measurements [4, 11, 26], the measured impedance vs. frequency characteristics for grassland and for non-grass vary widely [8].

Attempts have been made to characterize this variation by means of flow resistance [30]. However, this single parameter is not adequate to generate all of the impedance characteristics [8].

CONCLUSIONS

There is a need for further reliable measurements of the propagation of noise from surface transport sources under acoustically-neutral atmospheric conditions over finite-impedance ground planes and of the acoustic properties of these surfaces or of ground cover in order to substantiate the theoretical predictions. The extent to which impedance discontinuities or variations in acoustic properties from point to point influence near-grazing sound propagation also needs further investigation.

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles inlcude technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains an article about vortex shedding from cylinders and the resulting unsteady forces and flow phenomenon.

Ms. S.T. Fleischmann and Professor D.W. Sallet of The University of Maryland, College Park, Maryland has written the first part of a two-part paper that presents an extensive review of the unsteady flow phenomena that occur on and near cylinders in cross flow and that are related to related to vortex shedding. Part I contains an introduction to the phenomenon of vortex shedding from cylinders and the Karman vortex street.

VORTEX SHEDDING FROM CYLINDERS AND THE RESULTING UNSTEADY FORCES AND FLOW PHENOMENON PART I

S.T. Fleischmann and D.W. Sallet[1]

Abstract. This two-part paper presents an extensive review of the unsteady flow phenomena that occur on and near cylinders in cross flow and that are related to vortex shedding. Part I contains an introduction to the phenomenon of vortex shedding from cylinders and the Karman vortex street. The relation between the formation of the vortex street and the forces on the cylinder is discussed, as are the flow regimes of vortex shedding from stationary, circular cylinders. A flow regime is here defined as a Reynolds number range that is characterized by a particular experimentally obtained relationship of the Strouhal number to the Reynolds number.

In a recent two-part review article Chen gave an extensive overview of the entire subject of flow-induced vibrations of circular cylindrical structures in cross and in parallel flow [1, 2][2]. He also reviewed the modeling of the dynamic response of cylindrical structures in cross flow. The present article reviews unsteady flow phenomena that occur on and near cylinders in cross flow and that are related to vortex shedding. For a review of dynamic response models the reader is referred elsewhere [2, 3].

The basic phenomenon of vortex shedding is best illustrated by the flow of a viscous fluid such as water or air past a cylinder. At very low speeds the flow does not separate and the body has practically no wake, as shown in Figure 1. The velocity V at which such a flow pattern is established depends upon the diameter of the cylinder, D, the density of the fluid ρ, and the absolute viscosity of the fluid μ.

It is customary to combine these four variables into a dimensionless combination called the Reynolds number Re, where $Re = \frac{\rho V D}{\mu}$. The Reynolds number, named in honor of the 19th century English researcher Osborn Reynolds, represents the ratio of the inertial forces to the viscous forces acting on fluid particles in a flow field.

The range of Reynolds number in which the stream lines around the cylinder resemble the flow pattern shown in Figure 1 is $0 < Re \leq 3$. Flows of such low Reynolds number are seldom of technical interest within the topic under discussion. The flow velocity, for instance, for a cylinder of one in. diameter in 60°F water at a Reynolds number of three is only 0.0004 ft/sec.

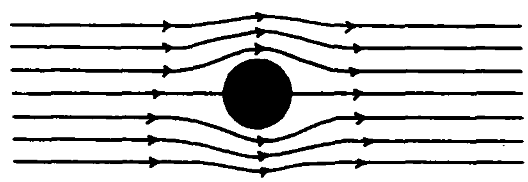

Figure 1. Schematic of Flow Past a Cylinder without Separation, $Re \leq 3$.

If the free stream velocity (undisturbed approach velocity of the flow) is increased, the flow near the cylinder separates, and two symmetrical vortices form on the downstream side of the cylinder as shown in Figure 2. The two vortices stay attached to the cylinder within the approximate Reynolds number range $3 < Re \leq 40$ [4]; again little or no wake is observed. The size and location of the two symmetrical attached vortices depends upon the Reynolds number. Within this regime, the higher the Reynolds number the larger the vortices and the further the distance between the vortex center and the rear stagnation point of the cylinder. According to Föppl [5], the vortex centers lie on two paths

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[2] *A complete list of references will follow Part II.*

that are symmetrical to the rear stagnation stream line. The paths are tangential to lines of ±45° through the rear stagnation point and asymptotically approach lines of ±30° through the center of the cylinder (see Figure 3).

When the Reynolds number exceeds a value of approximately 40, the vortices shed in alternating fashion and form a highly structured wake behind the cylinder called the Karman vortex street, as shown in Figure 4. It is this alternate shedding of vortices that causes a fluctuating force on the cylinder. The unsteady force has components in the direction of flow (drag force) and perpendicular to the direction of flow (lift force). The frequency with which the individual vortices are shed is proportional to the ratio U/d, so that $f = S\frac{U}{D}$, where the constant of proportionality S is called the Strouhal number [6]. The Strouhal number S is generally a function of the Reynolds number for a given cylindrical shape.

KARMAN'S VORTEX STREET

In 1912 Theodore von Karman [7] published the now classical paper on fluid dynamic drag that led to naming a wake of regularly staggered vortices a Karman vortex street. (The exact translation into English of the title of the paper is: "On the Mechanism of Liquid - and Air Resistance.") This paper contains two major contributions: one deals with the stability and arrangement of the individual vortices in the vortex wake; the other deals with the

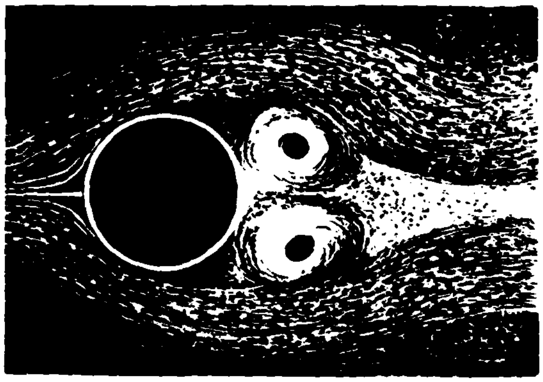


Figure 2. Flow Visualization; Flow Past a Cylinder with Two Attached Symmetrical Vortices, $3 < Re < 40$.

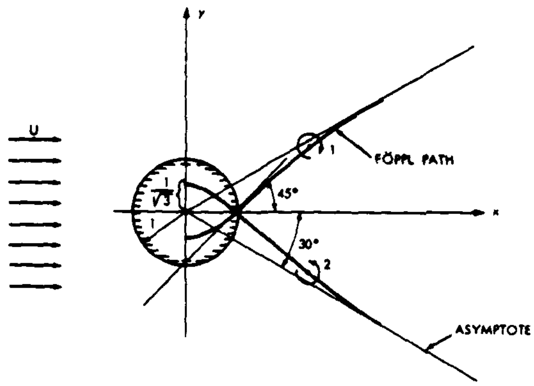
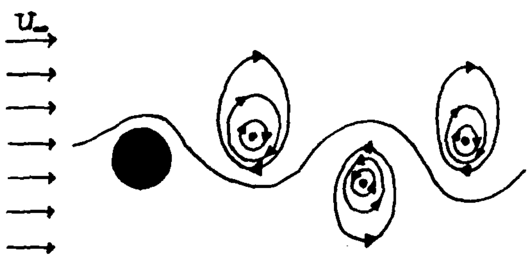


Figure 3. Foppl Path: Path of the Attached Vortex Centers as Reynolds Number Increases.



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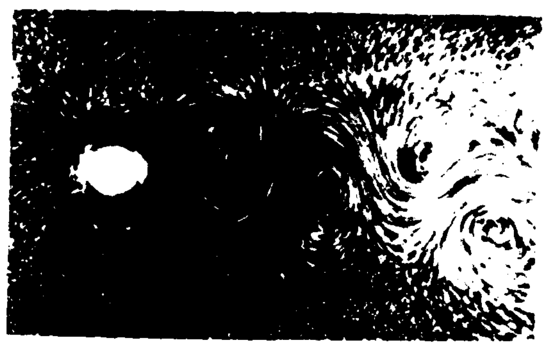


FLOW VISUALIZATION

Figure 4. A Karman Vortex Street.

drag experienced by a cylindrical body that causes such a Karman vortex street.

The arrangement of the individual vortices in the vortex wake behind cylindrical bodies was first studied by Bernard [8]. Bernard's work was solely experimental, but von Karman [7, 9, 10] used potential flow theory to show that any vortex wake other than one consisting of a staggered double row of vortices is unstable and therefore cannot exist. Within this stability analysis von Karman found that the vortex spacing ratio h/ℓ must satisfy the relation: $\cosh\left(\frac{\pi h}{\ell}\right) = \sqrt{2}$; i.e., $h/\ell = 0.28$ [9]. Von Karman later revised his first approach [10] and then restated his results and supported them with experimental data [7]. The stability and description of vortex streets were the topics of many subsequent investigations; the review article by von Krzywoblocki [11] cites more than 230 references on this subject.

The relation between the formation of the vortex street and the drag experienced by the cylindrical body was the second major contribution in von Karman's classical work. Because this computation can be extended to estimate unsteady drag and lift and because of the fundamental importance of this analysis to the subject discussed in this review article, the principal lines of thought and results are restated below.

Analysis. The vortex shedding cylinder and a large number of vortices are considered in a control volume as shown in Figure 5. An infinite double row of staggered vortices with a spacing ratio of h/ℓ will have a self-induced propagation velocity of

$$V_s = \frac{\Gamma}{2\ell} \tanh \frac{\pi h}{\ell} \tag{1}$$

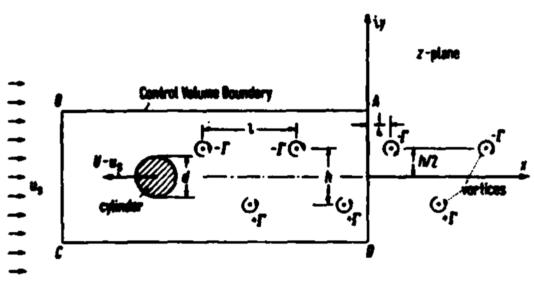


Figure 5. Control Volume Used in the Analysis of Lift Forces and Steady Drag Forces.

where Γ is the circulation of one vortex within the wake. The direction of the induced velocity of the vortex street shown in Figure 5 is along the negative x-axis. In order to make the vortex street stationary, a flow with velocity u_s is superimposed to the right. The control volume is fixed to the vortex street; i.e., with the superimposed velocity the control volume is now also stationary with respect to the observer. The velocity of the cylinder, originally U to the left, is now $(U - u_s)$ to the left inside the fixed control volume.

The calculation of the forces acting on the cylinder due to the generation of the vortices follows from the momentum principle which states: the resultant force acting on the control volume is equal to the rate of increase of linear momentum within the control volume plus the net effect of linear momentum from the control volume. The evaluation of the steady drag force terms was given by von Karman [7]; the evaluation of the lift force terms was given by Sallet [12, 13]. An evaluation of the unsteady drag forces from such a momentum analysis is currently in progress by the authors. In general, the unsteady drag forces are small when compared to the steady drag force.

The steady drag force on a stationary cylinder per unit length is:

$$F_D = \rho\Gamma \frac{h}{\ell}(U - 2u_s) + \rho \frac{\Gamma^2}{2\pi\ell} \tag{2}$$

and the peak lift force is:

$$F_L = \tfrac{1}{4}\,\rho\,\Gamma\,(U - 3u_s) \tag{3}$$

Define the coefficients of drag and lift in the customary manner -- namely, as the ratio of the drag or lift force and the product $(\tfrac{1}{2}\rho U^2 d)$ -- and substitute equation (1) to obtain the following expressions:

$$C_D = \frac{4}{d}\left[h\left(1 - \frac{S\ell}{d}\right)\left(\frac{2S\ell}{d} - 1\right)\coth\frac{\pi h}{\ell} + \frac{\ell}{\pi}\left(1 - \frac{S\ell}{d}\right)^2 \coth^2\frac{\pi h}{\ell}\right] \tag{4}$$

and

$$C_L = \frac{\ell}{d}\left(1 - \frac{S\ell}{d}\right)\left(3\frac{S\ell}{d} - 2\right)\coth\frac{\pi h}{\ell} \tag{5}$$

The dependence of the Strouhal number, S, was introduced into expressions (4) and (5) by the relation:

$$\frac{U - u_s}{U} = S\frac{\ell}{d} \qquad (6)$$

as was discussed by Sallet [15]. It is seen that both the coefficient of drag C_D and the coefficient of lift C_L are dependent upon the geometry of the vortex street; i.e., the spacing ratio h/ℓ and the Strouhal number S.

Evaluation of the lift or drag coefficient requires experimental determination of the value of the Strouhal number S. The value of h/ℓ can be von Karman's value of $h/\ell = 0.28$; it can be derived from the Kronauer stability criterion ($\frac{\partial C_D}{\partial (h/\ell)} = 0$ where $\frac{u_s}{U}$ is constant [16]) or obtained experimentally. For circular cylinders the Strouhal number is a well known function of the Reynolds number (see figures 6 and 7).

The fact that the drag and lift coefficients are dependent upon the vortex shedding frequency and the vortex geometry within the wake makes it possible to develop a method for predicting the drag and lift forces on vibrating cylinders, provided the vibration of the cylinder determines the shedding of the vortices. Such a calculation method was first suggested and carried out by Sallet [12-14] and Griffin [17].

Experimental observations. Figures 8a and 8b show experimental values for the fluctuating lift. In Figure 8b the experimental values are compared to the theory by Sallet [13]. The input values C_D and S strongly influence the predicted lift coefficient. This in fact could explain the scatter of the experimental values.

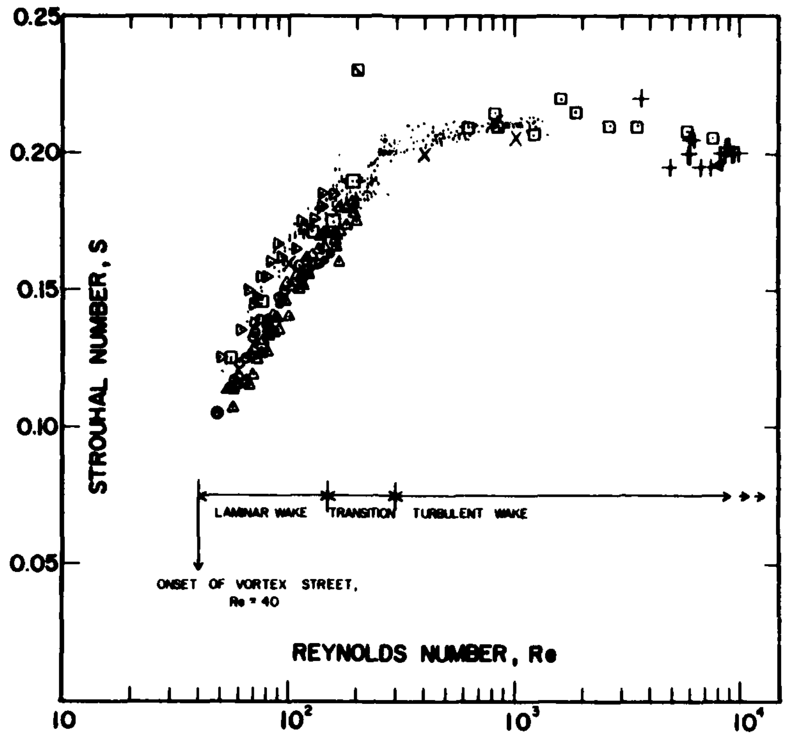
Figure 9 shows experimentally obtained unsteady drag coefficients. For reference the steady drag coefficient for a stationary circular cylinder is shown in Figure 10; additional values for the fluctuating and steady forces on a cylinder and S for $2 \times 10^4 < Re \leq 5 \times 10^4$ are available [18].

From Figures 8 and 9 it can be seen that the coefficient of fluctuating drag is very small, an order of magnitude smaller than the fluctuating lift coefficient. Considerable scatter in the values for fluctuating lift and drag coefficients is also evident. It should be noted that, although the steady drag results from temporal and spatial integration of the pressure drop behind the cylinder, the unsteady forces depend on a span-wise correlation of this pressure drop. The result is the formation of span-wise correlated vortices and flow that is basically two dimensional in nature. For this reason vibrations and end effects that effect the span-wise correlation of the flow would be expected to influence the periodic forces much more than the steady forces. Keefe [19] found that the fluctuating lift coefficient is indeed extremely sensitive to end conditions; however, the fluctuating drag coefficient is not as sensitive.

Okamoto and Yagita [20] studied the effect of the L/d (length to diameter) ratio on wake flow. They measured pressure distributions on the surface of a variable length cylinder with one free end in air and found that the vortex street existed for $L/d \geq 7$ but not for $L/d < 6$. They also reported that the flow separation line moved forward as L/d decreased for $L/d < 12$ and that the separation line was unchanged for $L/d > 12$. Parallel shedding was observed only for the center part of the cylinder in which two-dimensional flow seemed to occur. Slant-wise shedding occurred close to the free end. The study shows that two-dimensional flow – that is, a span-wise correlated vortex street – can be expected only for flow around long, slender cylinders. The study emphasizes the importance of end conditions to vortex shedding and therefore to periodic forces; this in turn emphasizes the need to examine experimental conditions carefully before experimentally obtained data are used.

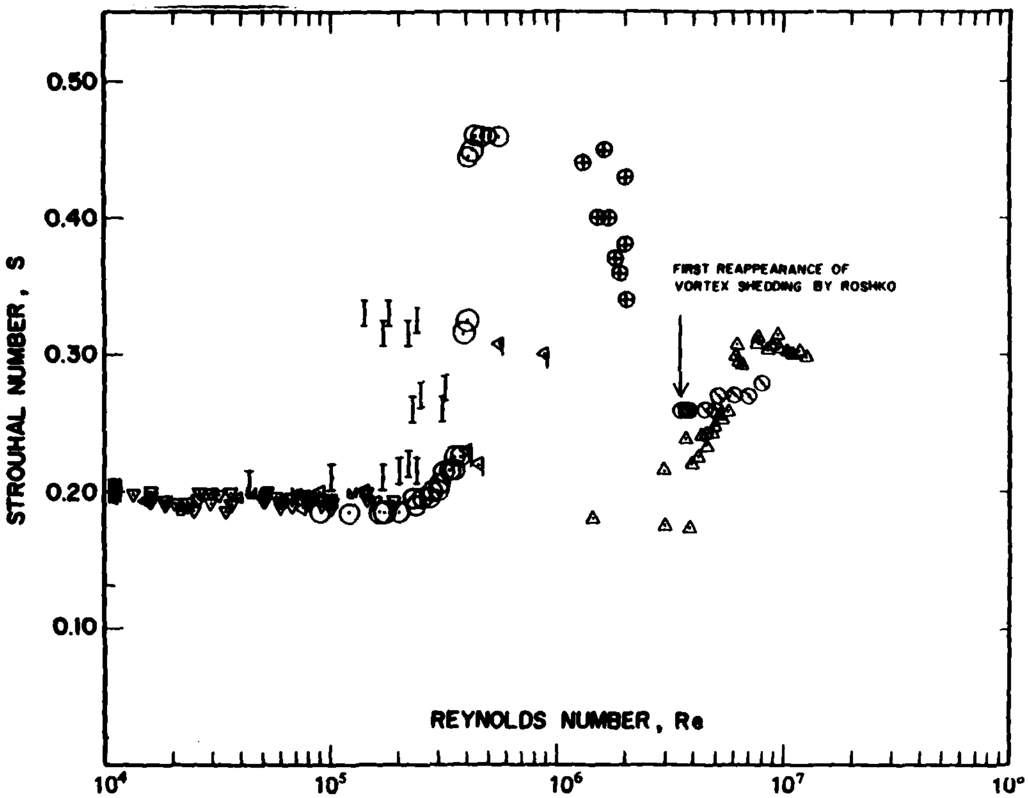
Many authors have found a random low frequency modulation of the direct lift force signal or the hot wire signal in the wake. The shedding frequency itself remains unchanged. Humphreys [21] showed that this low frequency modulation correlates with changes in the steady drag and concluded that this modulation is a result of changes in the wake width. Such an explanation is consistent with the expression for C_L developed by Sallet [12, 13].

Probable causes for changes in the wake width (lateral vortex spacing) are of interest. Hussain and Ramjee [22] observed a regular low frequency modulation of a hot wire signal in the wake of a cylinder. The modulation corresponded to a regular pulsation



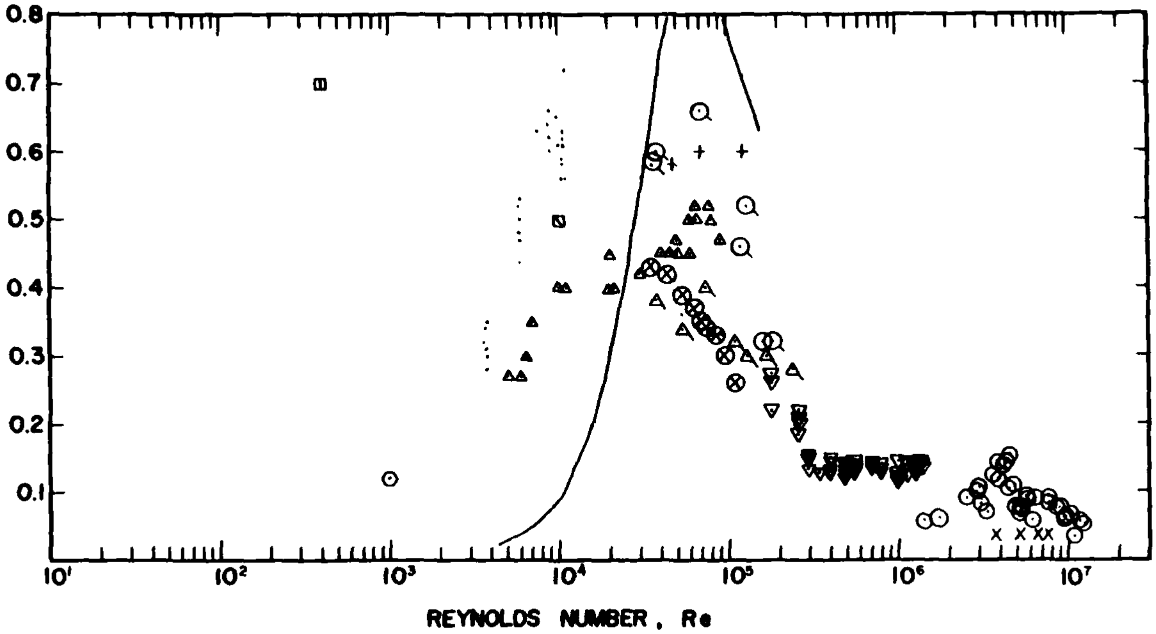
Investigator(s) Symbol	Re Range	Medium	Method of Measurement
Roshko ●	50 - 1380	air	hot wire anemometer (free stream velocity above 400 cm/sec measured using pitot tube, below 400 cm/sec by shedding frequency of a 2nd cylinder)
Kovaznay ⊡	55 - 7500	air	hot wire anemometer
Hanson ▷	49 - 140	air	hot wire anemometer
Nishioka and Sato ⊙	53 - 150	air	hot wire anemometer
Bishop and Hassan +	3.6×10^3 - 1.1×10^4	water	from strain gauge force measurement
Lugt and Haussling ⧅	200	-	calculation, flatplate = 45°
Jordan and Fromm X	100, 400, 1000	-	calculation
Gaster △	53 - 199	water	hot wire anemometer shedding from long, slender cones
Warren ◁	8.0×10^3 - 7.5×10^4	water	from strain gauge force measurements

Figure 6. Experimental Values of S(Re), Low Re Range.



Investigator(s) Symbol		Re Range	Medium	Method of Measurement
Roshko	⦸	$0.9 \times 10^6 - 8.0 \times 10^6$	air	hot wire anemometer
Jones, Cinciotta and Walker	△	$1.73 \times 10^6 - 1.29 \times 10^7$	air/freon	from unsteady lift measurement (spectral analysis)
Bearman	⊙	$9.0 \times 10^4 - 5.5 \times 10^5$	air	hot wire anemometer
McGregor		$4.38 \times 10^4 - 1.23 \times 10^5$	air	from force measurement using condenser-type microphones to measure pressure at various angles
Gerrard	▽	$8.3 \times 10^3 - 1.86 \times 10^5$	air	from fluctuating pressure measurements
Relf and Simmons	◁	$8.0 \times 10^4 - 8.9 \times 10^5$	air	hot wire measurement
Warren	◁	$8.0 \times 10^3 - 7.5 \times 10^4$	water	from strain gauge force measurements
Diana and Falco	⊠	$2.1 \times 10^4 - 2.47 \times 10^4$	air	hot wire anemometer and from cylinder mounted dynamometer measurements (spectral analysis)
Drescher	I	$4.3 \times 10^4 - 3.2 \times 10^5$	water	
Delany and Sorenson	⊕	$1.3 \times 10^6 - 2.0 \times 10^6$	air	pressure sensitive cell mounted in probe tip traversed in cylinder wake
Bishop and Hassan	+	$3.6 \times 10^3 - 1.12 \times 10^4$	water	from strain gauge measurements

Figure 7. Experimental values of S(Re), High Re Range.



Investigator(s) Symbol	Re Range	Medium	Method of Measurement
Bishop and Hassan ●	3.6×10^3 - 11.2×10^3	water	strain gauges on rotatable beryllium-copper beam cylinder supports
Jordan and Fromm ◫	400	-	calculation
Keefe △	5.0×10^3 - 9.0×10^4	air	direct force measurement using force transducer in instrumented section of 1 1/8 in. diameter cylinder
Takao ⬡	1000	-	calculation
Kuwahara ⧅	10,000	-	calculation
McGregor +	4.38×10^4 - 1.23×10^5	air	measured pressure coefficient every 10° around cylinder-integrated pressure distribution
Jones, Cinciotta, and Walker ⊙	1.42×10^6 - 12.42×10^6	air/freon	measurements made on 3 foot diameter cylinder using inertia-compensated balance (force transducers electrically subtracted inertia forces from accelerometer measurements)
Humphreys (ends sealed) ⌕ (ends open) △	4.0×10^4 - 6.0×10^5	air	6 in. diameter cylinder almost spanning 1 meter tunnel supported at top end, bottom end free, .05 in. from floor. force measurements with 3 load cells connected to supported end; 2 cells for lift, 1 cell for drag
Huthloff ⊗	3.0×10^4 - 1.0×10^5	air	strain gauge and inductive transducer measurement
Fung ▽	1.8×10^5 - 1.38×10^6	air	strain gauge measurement
Schmidt X	3.8×10^6 - 7.6×10^6	air	force obtained from static pressure transducer array measurements
Gerrard ———	4.47×10^3 - 1.58×10^5	air	from integration of pressure measurements

Figure 8a. Experimental rms Values of Unsteady Lift Coefficient vs. Reynolds Number.

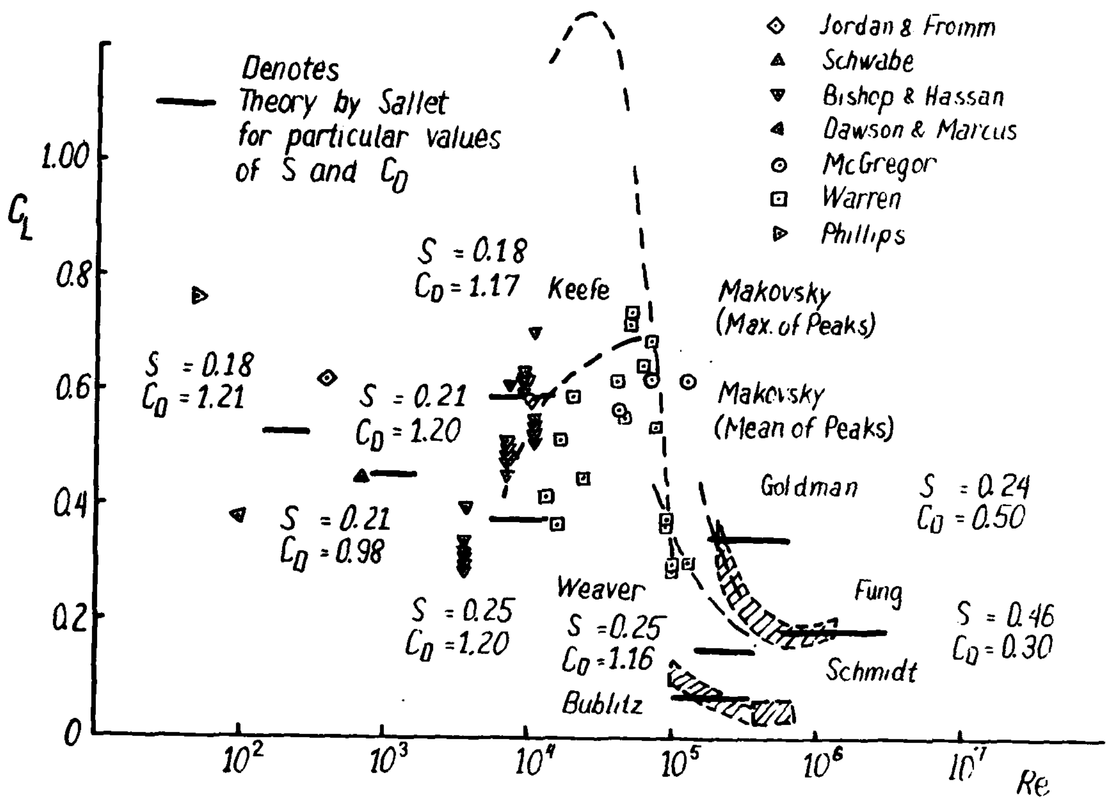
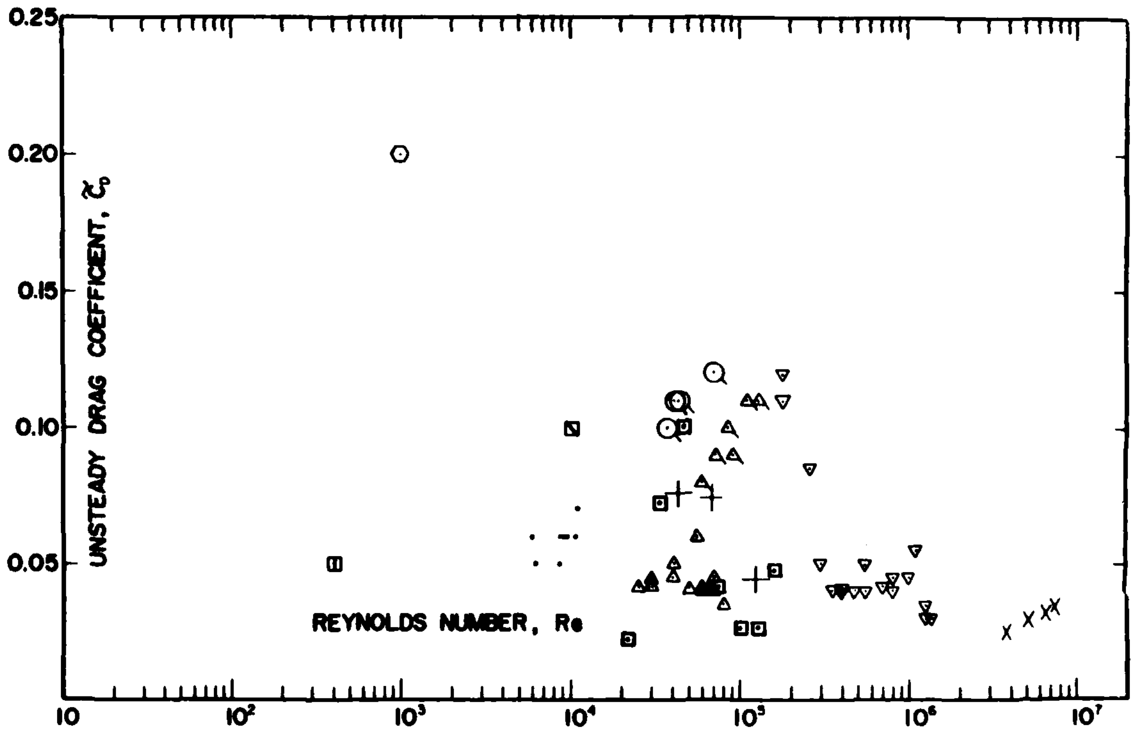


Figure 8b. Comparison between Experimental Absolute Values of Unsteady Lift Coefficient and Theoretical Predictions.



Investigator (s) Symbol		Re Range	Medium	Method of Measurement
Bishop and Hassan	●	$6.0 \times 10^3 - 1.1 \times 10^4$	water	direct force measurement using strain gauges on rotatable beam cylinder supports
Jordan and Fromm	◫	400	-	calculation
Keefe	◬	$2.2 \times 10^4 - 8.0 \times 10^4$	air	direct force measurement using force transducer in instrumented section of 1 1/8 in. diameter cylinder
Kuwahara	⧅	10,000	-	calculated
Takao	⎔	1,000	-	calculated
McGregor	+	$4.3 \times 10^4 - 1.2 \times 10^5$	air	measured pressure coefficient every 10° around cylinder-integrated pressure distribution
Humphreys (ends open) (ends sealed)	 ◬ ⨀	$3.7 \times 10^4 - 1.3 \times 10^5$	air	6 in. diameter polished aluminum cylinder almost spanning 1 meter tunnel-free at bottom (.05 in. from floor) measured moments on supported end with 3 load cells; 2 for lift, 1 for drag
Fung	▽	$1.8 \times 10^5 - 1.38 \times 10^6$	air	strain gauge measurement
Schmidt	X	$3.8 \times 10^6 - 7.6 \times 10^6$	air	force obtained from static pressure transducer array measurements
Gerrard	⊡	$2.14 \times 10^4 - 1.58 \times 10^5$	air	from integration of pressure measurements

Figure 9. Experimental rms Values of Unsteady Drag Coefficient vs. Reynolds Number.

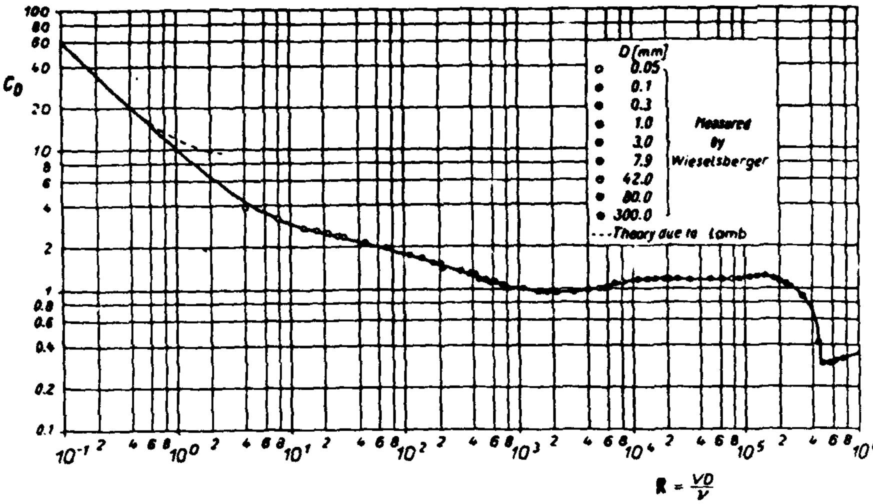


Figure 10. The Steady Drag Coefficient for Circular Cylinder C_D as a Function of Reynolds Number R [91].

of the free stream velocity. In the light of these observations the results of Schubauer and Skramstad [23], which demonstrate a correlation of stream-wise velocity fluctuations with blower noise, are of interest.

Toebes [24] noted a modulation of hot wire signals in the wake of a cylinder under forced oscillation at a frequency sufficiently far from the Strouhal frequency to avoid wake capture; the frequency seemed to correspond to a beat of the Strouhal with the oscillation frequency. Griffin [25] compared flow-excited and externally forced vibrating cylinders under conditions of wake capture and showed that the modulation is stronger for flow excited than for the forced cylinder vibrating at matched frequency and amplitude conditions.

Gaster [26] measured vortex shedding from slender cones and found an increasingly strong modulation with increasing Reynolds number. He concluded that in this case the low frequency modulation results from three-dimensionalities in the flow. Other data [27] show strong modulation for stationary cylinders; however, the modulation almost disappeared for cylinders freely vibrating under resonance conditions. Other investigators [28-30] showed that the wake width or lateral vortex spacing decreases for increasing cylinder amplitude and constant stream-wise spacing.

Flow visualizations by Thomas and Kraus [31] showed an expansion and contraction of the wake width behind a cylinder for certain critical spacings between that cylinder and an upstream cylinder. Rockwell [32] showed that a low frequency modulation of the signal in the wake of a square cylinder was due to separation and reattachment of the flow around the cylinder.

From the above observations it would seem that variations in the free stream velocity (which are related to three dimensionalities in the flow) are mainly responsible for the random low frequency modulation of the lift force and wake hot wire signals for stationary cylinders. In the case of vibrating cylinders the effects of vibration on the wake geometry and vortex shedding seem to strongly influence the low frequency signal modulation.

REGIMES OF VORTEX SHEDDING

The various regimes of vortex shedding from stationary circular cylinders are discussed in this section. A regime is characterized by a particular experimentally obtained relationship of the Strouhal number to the Reynolds number, $S = S(Re)$. It should be noted that each regime is also characterized by a particular appearance of the wake. The frequency of vortex shedding and the wake geometry

are closely correlated with the periodic force on the cylinder and are therefore of prime importance in the consideration of vortex induced vibrations. Experimental values of the Strouhal number for the various Reynolds number regimes are shown in Figures 6 and 7. These data summarize the results of many investigations.

Regime 1: 40 < Re < 150. Below Re = 40 an attached vortex pair is formed, and there are no vortices or other periodic disturbances of equal magnitude in the wake. Regime 1 ($40 < Re < 150$) is characterized by a laminar vortex street that forms behind the cylinder. The attached vortices persist in this regime but shrink in size as the Reynolds number increases until they disappear at a Reynolds number of about 90. Vortices are then shed directly from the cylinder.

Results vary slightly as to the exact value of the Reynolds number at which vortex shedding first occurs. Roshko [33] and most other investigators find that shedding begins at $Re \cong 40$; Nishioka and Sato [34], in recent careful measurements that covered a Reynolds number range of 20-120, found no shedding before Re = 48. Their explanation for this variation was that the onset of shedding is influenced by the level of free-stream turbulence, an explanation that is well supported by their experimental evidence.

Several different formulas relating the Strouhal number and Reynolds number in this regime can be found in the literature, they are given in the table. It is of interest to note from Figure 6 that, within the limits of experimental data scatter, evidence exists for at least two different relationships of $S = S(Re)$ in the low Re number range. The data from Nishioka and Sato [34] and from Gaster [26] are in very good agreement with each other but seem to be systematically lower than those of other investigators. The fact that these data have been collected by investigators in completely independent experiments suggests the possibility of two physically different modes of flow in this Reynolds number range.

The possibility of two different modes of vortex shedding has been the subject of much discussion since Tritton [36] published evidence of a transition in the mode of the vortex street at a Reynolds number of about 90, and especially since Gaster did not find this transition. Tritton observed that below the transition, in what he called the low speed

TABLE. Relationship of Strouhal Number and Reynolds Number: $\left(S = A - \frac{B}{Re} + C(Re)\right)$. Values of A and B and C are Given.

A	B	C	Author	Reference
0.195	3.92	0.0	Rayleigh	35
0.198	3.9	0.0	Tyler	35
0.212	4.5	0.0	Roshko	33
0.224	6.7	0.0	Tritton (High speed mode)	36
0.144	2.1	0.00041	Tritton (Low speed mode)	36
0.22	7.4	0.0	Berger (Basic mode)	37, 41
0.187	4.15	0.0	Marrow and Kline	38
0.19 - 0.216	2.6 - 5.77	0.0	Kohan and Schwarz	39

mode, the vortices were due to a wake instability developed from flow around the cylinder and its attached vortices. Above the transition, in what Tritton called the high speed mode, the vortices were shed directly from the cylinder. The two modes could be visually distinguished by more or less closely packed vortices.

At Euromech 17 in 1970, Tritton and Gaster discussed this discrepancy in experimental data. A report of their discussion is found in a review of that meeting [40]. This discussion and subsequent investigations by Tritton, Gaster, and others have been reviewed [37]. Tritton [41] later published a paper in which he discussed various reasons why Gaster did not observe the flow transition. Tritton pointed out that it was possible that his low speed mode and Berger's basic mode are actually the same, a possibility with which he noted Berger agreed.

The measurements of Nishioka and Sato [34] seem to confirm that their observations up to a Reynolds number of 120 is indeed Tritton's low speed mode. They showed that the length of the standing vortex pair increases linearly with increasing Re until vortex shedding begins. From that point the standing vortices are still observed but decrease gradually in length as the Reynolds number increases. These observations were confirmed by earlier results [42].

In the Re range for which a vortex street was observed to form behind a stationary cylinder (Re $>$ 48) Nishioka and Sato [34] found a short downstream distance over which stream-wise velocity fluctuations grow exponentially. Their data seems to show that the distance of exponential growth corresponds roughly to the length of the standing vortex pair. Exponential growth suggests the application of linear stability theory to flow in which an attached vortex pair and a vortex street coexist. In the Re range of 20 to 48 they observed that a vortex street could be induced for small amplitude ($a/d < 0.08$) forced vibrations at certain selected frequencies. They also found that, within those amplitude and frequency limits, the region in which the stream-wise velocity fluctuations grow exponentially exists just as it does for the stationary cylinder with a vortex street.

Nishioka and Sato [34] applied linear stability theory to their measurements of the exponential growth region behind slightly vibrating cylinders. They found the non-dimensional, forced vibration frequency β_{max} for which the streamwise fluctuation growth is a maximum. Here $\beta \equiv \frac{2\pi fb}{U_\infty}$; f is the frequency of forced vibration, b is ½ of the experimentally measured wake width, and U_∞ is the free-stream velocity. The β_{max} was found to be $\cong 0.5$ for various Re numbers. Using β_{max} and an experimentally determined value for b they were able to calculate the Strouhal number, $S = \frac{fd}{U_\infty} = \beta_{max} \left(\frac{d}{2\pi b}\right)$.

The calculations show excellent agreement with the Strouhal numbers obtained directly by experiment in the Re range of 48 to 120. The results of Nishioka and Sato are important because they show that, in this flow mode, which appears to be Tritton's low speed mode, the mechanism of vortex shedding is associated with the growth of small fluctuations at a particular frequency -- that for maximum growth as determined from linear stability theory.

Gerrard [43] investigated the mechanism of vortex shedding at higher Reynolds numbers. He concluded that the growing vortex is fed by circulation from the separated shear layer until the vortex is strong enough to pull the other shear layer across the wake. The vortex sheds as vorticity of opposite sign approaches in great enough concentration to cut off a further supply of circulation. Gerrard's observations were confirmed by the flow visualizations of Griffin and Ramberg [30] for a cylinder under small amplitude forced vibrations at Re = 190.

The experiments of Jaminet and Van Atta [44], who observed the flow field around a rotating cylinder in uniform cross flow, give further evidence of the two separate flow modes. They showed that, as the rotation speed of the cylinder increases, one side of the vortex street is swept into the other side and the formation of the vortex street is eventually suppressed. They found that the suppression parameter Ω (Ω is the ratio of tangential cylinder speed to undisturbed free-stream velocity) increases gradually up to an Re of about 80 and then remains constant for higher Re numbers. This result is consistent with the disappearance of an attached vortex pair at Re $\cong$ 80 because the shrinking attached vortex pair would effectively alter the cylinder shape.

A relatively large amount of space has been devoted to the regime in which vortex shedding first occurs,

since the evolution of the periodic vortex street is very important. At low Re a standing vortex pair forms behind the cylinder. Free-stream turbulence or other effects cause a wake instability that eventually results in the formation of a vortex street whose period is determined from considerations of linear stability theory. The attached vortex pair shrinks as the Reynold's number increases and eventually disappears. The alternating pattern, which has already been established, then continues throughout the remaining regimes of vortex shedding in the manner described by Gerrard [43].

It is noteworthy that a flow discontinuity can be seen in some of Roshko's data [33] for individual runs using different cylinders. The discontinuity appears at different Re numbers for each run and is possibly influenced by free-stream turbulence, the different cylinder diameters, or other variations in experimental conditions. If the discontinuity is generally sensitive to experimental conditions, a data presentation including many runs would show the discontinuity as normal data scatter, as was noted by Tritton [36].

Regime 2: (150 $\leqslant$ Re $\leqslant$ 300). In regime 1 the flow around the cylinder and in the cylinder wake is laminar. The second regime is marked by a transition of turbulence in the separated shear layers [33]. Transition occurs downstream of separation but before the roll up of the first vortex; the fluid making up the vortex is thus turbulent. This transition has actually been observed by Schiller and Linke [45], who found that the distance from separation to transition decreases as the Reynolds number increases. They also found that, at a given Reynolds number, this distance decreases for increasing free-stream turbulence. Regime 2 ends when the transition point reaches the flow separation point on the cylinder.

Regime 3: 300 $\leqslant$ Re $\leqslant 2 \times 10^5$ (approx.). Regime 2 ends and regime 3 begins when the point of transition to turbulence reaches the laminar separation point on the cylinder. Throughout regime 3 the boundary layers continue to undergo laminar separation at a point about 80° from the forward stagnation point. Vortex shedding continues unchanged, the appearance of the wake is unchanged, and the lift and drag coefficients of the cylinder are almost unchanged throughout this regime. The Strouhal number is constant at a value of about 0.20. This regime ends when the transition to turbulence occurs in the boundary layer on the cylinder at Re $\approxeq 2 \times 10^5$. Many flows of interest in engineering applications fall into this extensive Reynolds number range of constant Strouhal number.

Regime 4: $2 \times 10^5 \leqslant$ Re $\leqslant 3.5 \times 10^6$. The beginning of regime 4 is marked by a transition to turbulence in the boundary layer on the cylinder. As a result, the separation angle increases and the wake closes. Closely correlated with the closing of the wake is a significant decrease in the steady and periodic forces on the cylinder. Bearman [46] separates this regime into a central range, in which the drag coefficient drops but regular narrow-band vortex shedding continues, and a super-critical range in which this narrow-band vortex shedding is not observed.

Bearman [46] used a very smooth cylinder to detect narrow-band shedding up to a Reynolds number of 5.5×10^5. In the first part of the critical range he observed that the Strouhal number rises gradually from about 0.19 at Re = 2×10^5 to about 0.22 at Re = 3.6×10^5. Around Re = 3.5×10^5, a discontinuity was noted in which the Strouhal number rose abruptly to about 0.32. At approximately Re = 4×10^5 a second discontinuity occurred in which the Strouhal number jumped to a value of about 0.45. The Strouhal number stayed constant at this level up to the cessation of narrow-band shedding at Re = 5.5×10^5.

The first discontinuity corresponded to the formation of a laminar separation bubble on only one side of the cylinder; the bubble gave rise to steady lift in addition to the fluctuating lift. This phenomenon of steady lift on a circular cylinder has also been observed by others [47]. The second discontinuity corresponded to the formation of a second laminar separation bubble on the other side of the cylinder; this bubble eliminated the steady lift.

Bearman commented that, although he observed regular shedding up to Re = 5.5×10^5, the flow was extremely sensitive to small disturbances. They would locally trip the turbulent boundary layer causing gross three dimensionality in the flow that in turn caused the cessation of narrow-band shedding. Other investigators [47, 48] have also noted the extreme sensitivity of flow to small disturbances. In one case

[47] an oil-film visualization technique actually showed a turbulent wedge occurring ahead of the laminar separation bubble. This extreme sensitivity to small disturbances could account for the observed scatter of data in this regime.

Schlinker, Fink, and Amiet [49] have investigated the limits of regime 4 as a function of cylinder surface roughness. They found that both the lower and upper limits shift to lower Reynolds numbers in such a way as to decrease the extent of this regime as surface roughness increases.

Regime 5: $Re > 3.5 \times 10^6$. Above $Re = 3.5 \times 10^6$ narrow-band vortex shedding is reestablished. Regime 5 extends to the highest Reynolds numbers experimentally obtained to date in vortex shedding experiments, $Re = 1.1 \times 10^7$. The reestablishment of vortex shedding at high Reynolds numbers was first observed by Roshko [50]. An extensive study of flow in this regime has been done [47]; results were in agreement with those of Roshko on the lower limit of this regime, $Re = 3.5 \times 10^6$. Studies showed that the Strouhal number is again constant at a value of about 0.267. Correspondingly the wake opens again but not as far as in regime 3.

BOOK REVIEWS

ROOM ACOUSTICS

H. Kuttruff
Applied Science Publishers, Ltd., London, UK
2nd Edition, 1979, 309 pages

Six years after the initial publication of Room Acoustics, an updated second edition was issued. Most of the changes implemented in the second edition reflect the results of recent developments, primarily in the areas of psychoacoustics (Chapter VII) and measurement techniques (Chapter VIII). Other changes eliminate errors in the text and formulas.

In the introductory chapter the author derives the one-dimensional, first-order, linear wave equation and introduces the mathematical description of spherical propagation. He briefly mentions sound intensity, energy density, and acoustic power output. The reader is also introduced to Fourier transform theory; an interesting discussion on autocorrelation measurements of speech and music is included in this section. The frequency range and directional characteristics of natural sound sources – i.e., musical instruments and the human voice -- are also discussed.

The second chapter deals solely with the sound field near a boundary. The concepts of reflection coefficient, wall impedance, and energy absorption coefficient are applied to normal and oblique incidence plane waves impinging on an infinitely large wall. The pressure distribution in front of a rigid boundary for uniformly distributed incidence is derived assuming a random phase distribution, the application of which is discussed in Chapter III.

A very powerful tool in room acoustics -- modal analysis -- is applied in Chapter III. Although the classic rectangular room analysis is presented, several references are made to rooms of arbitrary shape. Statistical properties of the sound field in a room are discussed; emphasis is on the frequency and spatial variations of sound pressure level at steady-state conditions. Evident in this chapter is a continuous attempt by the author to apply mathematical conclusions to real situations; examples are used throughout the text. Other topics addressed in this chapter include eigenfunctions, modal density, damping constants, and reverberation.

Chapter IV deals with ray or geometrical acoustics. Image theory is used to describe the temporal distribution and reverberation in a three-dimensional closed space.

Chapter V relates the concepts of reverberation and energy density in a diffuse sound field. Specular reflections from walls are discussed as is the relationship between mean free path and room dimensions. An expression for the temporal decay of sound energy in a room is derived assuming statistically independent wall reflections. This chapter contains a very good treatment of coupled rooms, which are sometimes used to control the decay in a large auditorium.

Chapter VI deals with sound absorption mechanisms. Thermo-viscous losses at a rigid boundary, molecular relaxation in air, resonators, sound absorption of porous materials, and wedge linings in anechoic rooms are discussed. The effects of seats and audiences in concert halls are also analyzed; empirical data is presented from several different auditoria.

Chapter VII enters the realm of psychoacoustics. The subjective effects of single and multiple reflections in a room or concert hall are investigated from several aspects. As the author points out, conclusions are for the most part based on experimental investigations rather than from exact mathematical analyses. Topics include the perceptibility of a reflection as a function of angle of incidence with the listener, as a function of delay time, and as a function of strength of the reflection. This section also contains an excellent treatment of optimum reverberation times for various types of music (and speech). In this chapter the author has drawn on the works of more than 35 colleagues, with no

insignificant personal contribution, in what must be considered the highlight of the book.

Chapter VIII deals with measuring techniques. Methods for measuring reverberation time of a room, cross correlation between two points in a sound field, and energy absorption coefficients of materials are reviewed. Although the effectiveness of digital techniques is mentioned, surprisingly little attention is devoted to them.

Actual design considerations are treated in Chapter IX. The author successfully blends the subjective aspect and the physical properties of a sound field in the overall design of a concert hall. Geometrical acoustics are considered with respect to direct and reflected energy as a function of room shape. General guidelines on the control of reverberation time are given as well as an interesting discussion on the use of acoustical modeling.

The final Chapter deals with electroacoustic reinforcement, which is usually used in public address systems. The use of multichannel reverberation systems is briefly discussed; the system installed in the Royal Festival Hall in London is cited.

The diverse field of room acoustics requires not only the technical analytical skills of the physicist but the insights of the psychoacoustician as well. Although many texts address the physical complexities created by a sound field in an enclosure, few are able to successfully combine them with the subjective response of the listener. Kuttruff has provided the interested reader with a contemporary analysis that skillfully and satisfactorily performs this task and is well referenced and very readable.

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VIBRATIONS AND WAVES IN PHYSICS

I.G. Main
Cambridge University Press, NY
1978, 350 pages, $37.50 H.C., $8.95 P.C.

The book is available in both paperback and hard cover form. It is aimed, according to the author, primarily at an undergraduate physics student who should have a working knowledge of calculus, complex algebra, and both elementary partial and ordinary differential equations. The readership should be extended to engineers -- undergraduate students, graduate students, or mid-career engineering graduates – who need a refresher in wave theory and who are interested in focusing on the physics of vibrations and waves without any particular application (selected simple physics problems are used in illustrative examples).

The book is divided into two parts, the first of which is on elementary vibrations; the second is on various wave-related phenomenon. The portion on elementary vibrations is good, but texts of equal quality can be found elsewhere. However, the part on waves in physics is exceptionally well written. It covers both conventional wave topics and such advanced topics in wave propagation as dispersion, evanescent waves, wave groups, attenuation and DeBroglie waves. These topics are presented in an easy-to-understand format that includes simple examples of the phenomenon under consideration. Detailed explanations of the physical implications of the wave process under consideration are based on deductions from solutions of governing partial differential equations (usually one dependent variable and two independent variables of space and time). The examples are always supplemented with clear figures that illustrate the principal points involved.

Chapters 1 through 8 cover such conventional vibration topics as free vibrations, damping, forced vibrations, anharmonic vibrations, and two-coordinate vibrations. Chapters 9 and 10 treat non-dispersive waves and include such topics as traveling waves, standing waves, energy propagation, attenuation, longitudinal waves, acoustic waves, and cable waves. Chapter 11 contains concise coverage of Fourier theory and its relationship to wave theory. Chapter 12 covers dispersion related subjects: stiff springs, lumpy strings, and evanescent wave problems. The author provides a clear explanation of evanescent waves and refers to a stiffened string example problem having a low frequency cut off. Chapter 13 treats water wave topics including the nature of water wave motion and water wave depression. Chapter 14 is a short chapter on electromagnetic waves in a vacuum, in a dielectric media, and in a

plasma. Chapter 15 covers DeBroglie wave functions; particular physical applications in particle physics are given. Chapters 16 and 17 consider such acoustic-related phenomena as reflection and refraction at boundaries, standing waves in an enclosure, features due to the arrangement of diffraction centers (e.g., slit problems) and features dependent on the nature of diffraction centers.

In summary, the text is an excellent overview of practically all the important physical and mathematical concepts within the general topic of waves in physics. The book is highly recommended to those learning these concepts for the first time and to those needing a review of important wave related items.

A.J. Kalinowski
Naval Underwater Systems Center
New London, CT 06320

ENGINEERING APPLICATIONS OF CORRELATION AND SPECTRAL ANALYSIS

J.S. Bendat and A.G. Piersol
John Wiley and Sons, New York, NY, 1980

Stochastic process data analysis has grown by leaps and bounds in the past ten years. Relatively inexpensive digital computers process data quickly, and new concepts in modeling and interpreting results are constantly being developed. This text supplements the theory and data processing procedures of the authors' previous book, Random Data: Analysis and Measurement Procedures, which has been an authoritative text for a decade.

Although the authors assume that the reader has a working basic knowledge of analyzing and processing random data, they start from scratch. The basic characteristics of random data, Fourier transforms, and physical system response are considered. Random data involves statistics, and the authors present probability theory clearly. They describe spectral and correlation functions and show their relationship. Procedures for analyzing single input/single output relations are described. Stationary and transient random inputs are given, as are the effects of measurement noise, including the direct effect on data.

The problem of estimating the response function and random and bias errors is not a simple one. The authors propose valid explanations and demonstrations and leave no uncertainties. The chapter concludes with an interesting explanation of system response predictions for both single-degree-of-freedom and distributed systems.

The propagation of energy from one location to another along a number of paths is considered. Frequency response functions produce the correct linear relationship but do not provide a means for identifying the contributions of individual paths. Cross correlation and cross spectra furnish partial answers; noise and scattering effects are limiting.

Mixed paths and multiple paths demand a more direct procedure. Single input/multiple output problems require the correlation method; it helps to pinpoint the dominant location and source of energy. Reverberation and scattering distort the information, but proper calibration of equipment greatly reduces the signal processing problem.

Multiple input/output relations utilize partial coherence to provide a measure of linear dependence between a collection of inputs and an output that is independent of the correlation of the inputs. A major application of multiple input/output relationships is to identify energy sources. The problems of simple paths become more complicated. Additional problems include accurately guessing the location of significant sources, reaching them with a transducer, and devising an appropriate transducer to measure them. The last could be the most difficult, as in the case of distributed noise sources.

Partial coherence is a logical way to solve these problems. Coherence techniques are used to examine computational algorithms for efficient digital data processing operators. The two input system and the general case of multiple inputs are used.

Procedures for laboratory simulation of spectral density matrices can be represented by auto and cross spectra that might exist between an arbitrary number of multiple records. The final chapter describes the latest available approaches to practical statistical error analysis formulas required to compute spectral density functions, coherence functions, and frequency response functions needed to analyze

single input/output and multiple input/output problems.

In summary, the authors have written an exciting book. The latest concepts on partial coherence are given. Partial coherence helps to identify energy sources and has revolutionized testing and brought it closer to analysis.

The reviewer believes that partial coherence will assume a role of greater importance as more complex problems are presented and complete solutions are required. This book is one of very few concerning the role of partial coherence in modern random data analysis. It belongs on the desk of individuals interested in the theoretical aspects of stochastic processes and data analysis.

H. Saunders
General Electric Company
Schenectady, NY 12345

SHORT COURSES

DECEMBER

MACHINERY DATA ACQUISITION

Dates: December 7-11, 1981

Place: Carson City, Nevada

Objective: This seminar is designed for people whose function is to acquire machinery data for dynamic analysis, using specialized instrumentation, and/or that person responsible for interpreting and analyzing the data for the purpose of corrective action on machines. Topics include measurement and analysis parameters, basic instrumentation review, data collection and reduction techniques, fundamental rotor behavior, explanation and symptoms of common machinery malfunctions, including demonstrations and case histories. The week also includes a lab workshop day with hands-on operation of the instrumentation and demonstration units by the participants.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-3611, Ext. 224.

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: December 8-12, 1981

Place: Huntsville, Alabama

Dates: February 1-5, 1982

Place: Santa Barbara, California

Dates: March 1-5, 1982

Place: College Park, Maryland

Dates: April 12-16, 1982

Place: Dayton, Ohio

Dates: July 19-23, 1982

Place: England

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

JANUARY

PROBABILISTIC AND STATISTICAL METHODS IN MECHANICAL AND STRUCTURAL DESIGN

Dates: January 11-15, 1982

Place: Tucson, Arizona

Objective: The objective of this short course and workshop is to review the elements of probability and statistics and the recent theoretical and practical developments in the application of probability theory and statistics to engineering design. Special emphasis will be given to fatigue and fracture reliability.

Contact: Special Professional Education, Harvill Building No. 76, Room 237, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-3054.

MACHINERY VIBRATION ANALYSIS

Dates: January 26-29, 1982

Place: Tampa, Florida

Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation, and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific

components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow speed paper rolls.

Contact: Dr. Ronald L. Eshleman, The Vibration Institute, 101 West 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

FEBRUARY

VIBRATION TESTING AND SIGNAL ANALYSIS
Dates: February 16-18, 1982
Place: Southampton, England
Objective: Topics include: types of testing: introduction to the various types of signal-linear system theory, etc. (i) testing with applied excitation - techniques - steady state, slow sweep, transient, random, (ii) response analysis (only) - system in motion due to natural excitation; instrumentation and signal conditioning - effects of attachments on system characteristics; instrumentation system characteristics; limitations, e.g. bandwidth, integration, analogue filtering, etc.; signal processing; and specification testing.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton, S09 5NH - (0703) 559122, Ext. 2310.

BALANCING OF ROTATING MACHINERY
Dates: February 23-26, 1982
Place: Galveston, Texas
Objective: The seminar will emphasize the practical aspects of balancing in the shop and in the field. The instrumentation, techniques, and equipment pertinent to balancing will be elaborated with case histories. Demonstrations of techniques with appropriate instrumentation and equipment are scheduled. Specific topics include: basic balancing techniques (one- and two-plane), field balancing, balancing without phase measurement, balancing machines, use of programmable calculators, balancing sensitivity, flexible rotor balancing, and effect of residual shaft bow on unbalance.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MARCH

MEASUREMENT SYSTEMS ENGINEERING
Dates: March 1-5, 1982
Place: Phoenix, Arizona
MEASUREMENT SYSTEMS DYNAMICS
Dates: March 8-12, 1982
Place: Phoenix, Arizona
Objective: Program emphasis is on how to increase productivity, cost-effectiveness of data acquisition systems and groups in the field and in the laboratory. Emphasis is also on electrical measurements of mechanical and thermal quantities.

Contact: Peter K. Stein, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603/946-7333.

SHOCK AND VIBRATION CONTROL
Dates: March 16-18, 1982
Place: Southampton, England
Objective: Topics include: introduction - structural parameters and their role in vibration control; dynamic properties of structural materials - damping materials and their properties, application of damping treatments to structures, fibre reinforced plastics, fatigue; mobility methods - concepts, system coupling, application to the isolation problem, approximate methods; vibration transmission through structures - path identification - classical, cross correlation, etc., power flow - mechanisms, use of statistical energy methods, acoustic radiation, radiation efficiency; shock - impacts in machines - effects of structural parameters on acoustic radiation, isolation - machinery installations, the transient environment - packaging and packaging materials.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton, S09 5NH - (0703) 559122, Ext. 2310.

APRIL

DESIGN OF FIXED OFFSHORE PLATFORMS
Dates: April 5-16, 1982
Place: Austin, Texas
Objective: This course is dedicated to the profes-

sional development of those engineers, scientists, and technologists who are and will be designing fixed offshore platforms to function in the ocean environment from the present into the twenty-first century. The overall objective is to provide participants with an understanding of the design and construction of fixed platforms, specifically the theory and processes of such design and the use of current, applicable engineering methods.

Contact: Continuing Engineering Studies, College of Engineering, Ernest Cockrell Hall 2.102, The University of Texas at Austin, Austin, TX 78712 - (512) 471-3506.

INFORMATION RESOURCES

THERMOPHYSICAL AND ELECTRONIC PROPERTIES INFORMATION ANALYSIS CENTER (TEPIAC)
A Department of Defense Information Analysis Center

MISSION

TEPIAC is operated by the Center for Information and Numerical Data Analysis and Synthesis (CINDAS) of Purdue University. Its mission is to provide comprehensive, authoritative, and timely scientific and technical information analysis services on thermophysical and electronic properties of materials to the Department of Defense, other government agencies, government contractors, and also the private sector.

SCOPE OF COVERAGE

Materials
More than 100,000 materials are identified and listed in the TEPIAC Materials Directories. This coverage includes the elements, organic and inorganic compounds, alloys, intermetallics, glasses, ceramics, cermets, coatings, polymers, systems, composites, and many other groups.

Properties
A total of 14 thermophysical properties and 22 electronic, electrical, magnetic, and optical properties and property groups are under TEPIAC cognizance.

SOURCES OF INFORMATION

More than 250,000 bibliographic citations (publication dates 1850 to the present) are indexed and codified for rapid computer retrieval. Over 8,000 new publications are added each year to the thermophysical and electronic properties files. Scientific and technical journal articles account for about 92 percent of these file inputs. Government reports and other sources make up the remaining 8 percent of these inputs.

PRODUCTS AND SERVICES

Technical Assistance
The TEPIAC research staff has a broad based, extensive research experience in engineering and the physical sciences. Types of technical assistance available include: ***Data Evaluation*** where many conflicting data are found in the literature; ***Data Generation*** (prediction) where few or no data are known, and related ***Advisory and Consulting Services*** when desired.

Publications
Major publications are sold by well-known U.S. publishers. Minor publications, special technical reports, and reproductions of documents are sold direct from TEPIAC/CINDAS. Brochures that outline details and prices are available on request.

Retrospective Searches
To acquaint interested users with the TEPIAC rapid turnaround computer searches, the following four sample searches can be mailed free of charge:

Contents	Original Value
• Thermophysical Properties of Freon 502	$ 40
• Electronic Properties of Borosilicate Glasses	80
• Thermophysical Properties of the Composite: Al_2O_3/Epoxy	40
• Thermal Linear Expansion of Intermetallic Compounds	240
	$400

Currently a new publication is being considered which is the complete TEPIAC Materials Directory listed on microfiche directly from magnetic tape files. There are approximately 100,000 materials,

cross references, and synonyms in this directory. A copy of this directory would be very useful in requesting searches from TEPIAC. Also, this global master alphabetical list can acquaint all users with common names for materials vs scientific names, compositions, alloy names, and much more.

For further information, contact: Wade H. Shafer, CINDAS/Purdue University, 2595 Yeager Road, West Lafayette, IN 47906 - (800) 428-7675 or (317) 494-6300 or (317) 463-1581.

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see No. 2474)

81-2290

The Effect of the Shape of the Holes of the Rotor and Stator on the Acoustic Parameters of a Dynamic Axial Generator

A. Puch

Dept. of Acoustics of the Inst. of Physics, Pedagogical Univ., 35-310 Rzeszow, ul. Rejtana 16a, Arch. Acoustics, 5 (4), pp 369-380 (1980) 9 figs, 16 refs

Key Words: Noise generation, Rotors, Stators, Geometric effects

The paper presents the results of investigations concerning choice of the optimal shape (from the viewpoint of acoustical efficiency) of the holes of the rotor and stator of a dynamic axial generator, the horn and pressure chamber of which are common to all the stator channels.

81-2291

Rotordynamics Analysis for the HPFTP (High Pressure Fuel Turbopump) of the SSME (Space Shuttle Main Engine). SSME Turbopump Technology Improvements via Transient Rotordynamics Analysis

D.W. Childs

Louisville Univ., Louisville, KY, Rept. No. NASA-CR-161620, 63 pp (July 1980)

N81-15017

Key Words: Rotors, Pumps, Space shuttles, Spacecraft, Stiffness coefficients, Damping coefficients

The results of both linear (stability and synchronous response) and transient nonlinear analyses are reported. Dynamic coefficients were developed for the HPFTP interstage seals, and introduced into the rotordynamic model. The influence on HPFTP rotordynamics of a change in interstage seals from the smooth stepped design to a smooth straight configuration was examined. The sensitivity of the stability and synchronous results to changes in bearing stiffnesses and damping was determined. The influence on rotordynamic stability of a change from the stiff symmetric bearing carrier design to an asymmetric bearing carrier configuration was also studied.

81-2292

Transient Analysis of Rotor-Bearing Systems Using Component Mode Synthesis

H.D. Nelson and W.L. Meacham

Arizona State Univ., Tempe, AZ, ASME Paper No. 81-GT-110

Key Words: Rotors, Transient response, Component mode synthesis, Blade loss dynamics, Base excitation

A method of component mode synthesis is utilized to determine the forced response of linear multishaft rotor-bearing systems. The formulation allows for simulation of system response due to blade loss, base shock, maneuver loads, and specified fixed frame forces.

81-2293

Distribution of Movements in the Dynamics of Rotary Motions (Verteilung der Bewegungen in der Dynamik der Rotationsbewegungen)

A. Pissarev

VEB Werkzeugmaschinenkombinat "Fritz Heckert," Karl Marx Stadt, E. Germany, Maschinenbautechnik, 30 (5), pp 228-229 (May 1981) 2 figs, 5 refs

(In German)

Key Words: Rotating machinery, Machine tools, Mechanical drives

The author deals with dynamics of drives and deduces the so-called "method of distribution of movement." The method provides a closed solution of the differential equations describing the dynamic response of drives.

81-2294

A Parametric Study of Vibration of Rotating Pre-twisted and Tapered Low Aspect Ratio Cantilever Plates

S. Sreenivasamurthy and V. Ramamurti

Dept. of Mech. Engrg., Indian Inst. of Tech., Madras-600036, India, J. Sound Vib., 76 (3), pp 311-328 (June 8, 1981) 13 figs, 4 tables, 22 refs

Key Words: Plates, Cantilever plates, Variable cross section, Rotors, Natural frequencies, Finite element technique

A finite element technique has been used to determine the natural frequencies of a pre-twisted and tapered plate mount-

ed on the periphery of a rotating disc. The pre-twisted plate has been idealized as an assemblage of three noded triangular shell elements with six degrees of freedom at each node. In the analysis the initial stress effect (geometric stiffness) and other rotational effects except the Coriolis acceleration effect have been included. Computation of frequencies has been carried out for plates of aspect ratios 1 and 2. Other parameters considered are pre-twist, taper, skew angle and disc radius.

81-2295

Influence of Unequal Pedestal Stiffness on the Instability Regions of a Rotating Asymmetric Shaft

H. Ota and K. Mizutani

Faculty of Engrg., Nagoya Univ., Chikusa-ku, Nagoya, 464 Japan, Bull. JSME, 24 (190), pp 700-707 (Apr 1981) 11 figs, 2 tables, 5 refs

Key Words: Shafts, Variable material properties, Stiffness, Whirling

Two types of unstable vibrations occur because of the asymmetry in the shaft stiffness. To understand the mechanism for the occurrence of these unstable vibrations, the authors clarify the conditions necessary for their occurrence. A torque applied to a shaft end tends to increase the whirling amplitudes of the shaft. The conditions for instability of free vibration thus obtained are ascertained by an analog computer. If the higher order of small quantities, that is, the rotating asymmetry of shaft stiffness and inequality of pedestal stiffness, is taken into consideration, a number of very narrow instability regions can be made to occur.

81-2296

On Flexible Input Shaft and Flywheel Interaction in High-Speed Machines

R.C. Pandey and A. Midha

Dept. of Mech. Engrg., Pennsylvania State Univ., University Park, PA 16802, Mech. Mach. Theory, 16 (4), pp 321-337 (1981) 12 figs, 18 refs

Key Words: Shafts, Flexible shafts

While some elasticity in the coupling shaft between the driving motor and the machine input is desirable for attenuating the effects of misalignment, impact, etc., it is important to understand the resulting kineto-elastodynamic response of the machine for better design of the input shaft. An iterative approach is used to arrive at the steady-state response of a machine with an elastic driving shaft. Once the vibratory response is known, a parametric study is conducted that would aid in a better understanding and an optimal design of the input shaft and the flywheel. Parameters such as the angular twist per unit length and the frequency and damping ratios has been considered.

81-2297

Study and Experimental Tests of Fibrous Acoustic Treatment for Reduction of Fan Noise from XF3-1 Turbofan Engines

R. Sasaki, K. Ishizawa, and K. Higashi

Japan Defense Agency, Tokyo, Japan, J. Aircraft, 18 (6), pp 474-479 (June 1981) 12 figs, 2 refs

Key Words: Fan noise, Noise reduction, Fiber composites, Turbofan engines

The characteristics of an acoustic treatment employing fibrous material and its effect on fan noise reduction radiated from a turbofan engine have been studied. The predominant feature of the treatment is that it is composed of a fibrous layer backed with an air cavity, which facilitates control of the acoustic impedance of the treatment. This paper presents the design procedures for the treatment developed through this study and the results of the tests made to investigate its mechanical and acoustic properties.

81-2298

Transient Torsional Vibrations of a Rigid Mass Connected to an Elastic Half-Space by an Elastic Circular Rod

H. Wada

Dept. of Mech. Engrg., Tohoku Univ., Sendai 980, Japan, Intl. J. Mech. Sci., 23 (5), pp 285-295 (1981) 5 figs, 9 refs

Key Words: Mass-halfspace systems, Torsional vibration, Transient response, Pulse excitation, Laplace transformation

Applying the Laplace transformations and its numerical inverse, the transient torsional vibrations of a rigid mass connected to an elastic half-space by an elastic rod are analyzed under two specific incident pulse loads. The time histories of the rigid mass rotation are presented. Application of the numerical inverse Laplace transformations enables the calculation of the time histories of the rigid mass rotation accurately and fairly quickly by utilizing a digital computer.

81-2299

Transient Forced Vibration of Rotationally Periodic Structures

A.J. Fricker and S. Potter

Central Electricity Res. Labs., Leatherhead, Surrey, UK, Intl. J. Numer. Methods Engrg., 17 (7), pp 957-974 (July 1981) 5 figs, 2 refs

Key Words: Structures, Transient response, Substructuring methods, Modal analysis, Computer-aided techniques

The calculation of the response of rotationally periodic structures to transient forces and prescribed motions is considered. Only free and harmonic forced vibration problems were considered. It is assumed that the finite element method is to be used, so that the equation of motion of the structure contains a finite number of degrees-of-freedom whose responses are governed by mass, stiffness and damping matrices. A modal method of solving this equation is described. A brief description of the implementation of the method in a suite of computer programs, and the application of the programs to a practical problem, is also given.

81-2300

Rotational Vibration with Backlash – Part 2

C.C. Wang

Central Engrg. Lab., FMC Corp., Santa Clara, CA 95052, J. Mech. Des., Trans. ASME, 103 (2), pp 387-397 (Apr 1981) 25 figs, 3 tables, 6 refs

Key Words: Angular vibration, Multidegree of freedom systems, Pulleys

In this paper, the experimental results for the 3-mass system are presented. Physical simulation very close to an ideal limiting case where the driven pinion is linked to the output pulley with a very low stiffness shaft was performed. The nonlinear responses of a system with backlash and subject to impact and/or displacement excitation were obtained. The presence of multiple critical speeds for a single degree of freedom system under impact and/or displacement excitation has been analytically explained and experimentally confirmed. Computer solutions based on the piecewise linear iteration technique are used with a considerable degree of success. Computer predictions agree well with actual responses in various speed ranges despite a series of bold assumptions that were made to simplify the numerical process.

81-2301

Comparison of Experimental and Computational Shock Structure in a Transonic Compressor Rotor

G. Haymann-Haber and W.T. Thompkins, Jr.

General Electric Co., Lynn, MA 01910, J. Engrg. Power, Trans. ASME, 103 (1), pp 78-88 (Jan 1981) 19 figs, 17 refs

Key Words: Rotors, Compressors, Measurement techniques, Shock response

Measurement of passage shock strength in a transonic compressor rotor using a gas fluorescent technique revealed an unexpected variation in shock strength in the radial direction. Blade boundary layer separation originating at this point accounts for about one half of the total rotor losses. A numerical computation of the three-dimensional inviscid flow, using time-marching techniques, has accurately predicted in general the radial and tangential variations in passage shock strength and in particular the sharp pressure peak at the nominal sonic radius. This paper presents comparisons between the optical density measurements and computational results and in addition a short analytical discussion which demonstrates that the sharp shock strength rise may occur in many transonic compressor rotors.

RECIPROCATING MACHINES

(See No. 2457)

POWER TRANSMISSION SYSTEMS

81-2302

Investigation of Parametric Nonlinearities in Transmission Systems (Untersuchung von Parameternichtlinearitaten bei Ubersetzungsgetrieben)

M. Hortel and G. Schmidt

Thermomechanical Institute of the Czech. Akad. of Sci., CS 16000 Prague 6, Pushkin plaza 9, Czech. Soc. Rep., Z. angew. Math. Mech., 61 (1), pp 21-28 (Jan 1981) 9 figs, 6 refs

(In German)

Key Words: Transmission systems, Parametric excitation, Nonlinear systems, Gear drives

The influence of a non-linear time-dependent rigidity, a so called parametric non-linearity, is investigated in connection with an elastically supported geared transmission. The analysis of the main resonance with the integral equation method shows the important qualitative influence of parametric non-linearity. These properties can be used not only for machine design but also for improvement of existing machine parts.

81-2303
Constrained Fatigue Life Optimization of a Nasvytis Multiroller Traction Drive
J.J. Coy, D.A. Rohn, and S.H. Loewenthal
Propulsion Lab., AVRADCOM Res. and Tech. Lab., Lewis Res. Ctr., Cleveland, OH, J. Mech. Des., Trans. ASME, 103 (2), pp 423-429 (Apr 1981) 8 figs, 1 table, 15 refs

Key Words: Mechanical drives, Traction drives, Fatigue life

A contact fatigue life analysis method for multiroller traction drives is presented. The method is based on the Lundberg-Palmgren analysis method for rolling element bearing life prediction, and also uses life adjustment factors for materials, processing, lubrication, and effect of traction. The analysis method is applied in an optimization study to the multiroller traction drive, consisting of a single-stage planetary configuration with two rows of stepped planet rollers of five rollers per row.

'-2304
Simplified Fatigue Life Analysis for Traction Drive Contacts
D.A. Rohn, S.H. Loewenthal, and J.J. Coy
NASA Lewis Res. Ctr., Cleveland, OH 44135, J. Mech. Des., Trans. ASME, 103 (2), pp 430-439 (Apr 1981) 13 figs, 1 table, 25 refs

Key Words: Mechanical drives, Traction drives, Fatigue life

A simplified fatigue life analysis for traction drive contacts of arbitrary geometry is presented. The analysis is based on the Lundberg-Palmgren theory used for rolling-element bearings. The effects of torque, element size, speed, contact ellipse ratio, and the influence of traction coefficient are shown. The analysis shows that within the limits of the available traction coefficient, traction contacts exhibit longest life at high speeds. Multiple, load-sharing arrangements have an advantageous effect on system life, torque capacity, power-to-weight ratio and size.

81-2305
Some Methods to Reduce Noise in Toothed Belt Drives
M. Kagotani, T. Aida, T. Koyama, S. Sato, and T. Hoshiro
Osaka Industrial Univ., 3-1-1, Nakagaito, Daito-shi, Osaka, Japan, Bull. JSME, 24 (190), pp 723-728 (Apr 1981) 13 figs, 10 refs

Key Words: Belt drives, Noise reduction

The noise level of toothed belt drives is affected by the interference of belt and pulley teeth at the point where meshing on the driving pulley begins. A preferable amount of interference can be obtained by a suitable selection of the pitch difference between belt and pulley. The smaller the radius of the rounded tip corners of the pulley teeth, the lower the noise of the belt. Vibration due to the impact of the belt and pulley teeth at the point where meshing begins is almost never transmitted to the pulley.

METAL WORKING AND FORMING

(Also see No. 2293)

81-2306
Analysis of Grinding Dynamics by Dynamic Data System Methodology
E. Garcia-Gardea, S.G. Kapoor, and S.M. Wu
Ing. Mecanica ITESM Suc. "J", Monterrey, Mexico, Intl. J. Mach. Tool Des. Res., 21 (2), pp 99-108 (1981) 5 figs, 3 tables, 6 refs

Key Words: Grinding, Dynamic Data System technique, Machine tools

The Dynamic Data System (DDS) methodology is used to reveal the grinding process dynamics from the cutting force signal. The discrete DDS models are fitted to 16 sets of cutting force signals and the models as high as tenth order are obtained. From the analysis of the discrete models, the natural frequencies corresponding to characteristic subsystems such as machine tool and dynamometer, the effective grit pass and the grinding wheel contact dynamics are identified. An exploratory attempt is made to analyze the continuous DDS model leading into a qualitative interpretation of the possible coupling phenomena.

81-2307
Machine Tool Vibration – A Review
V. Ramamurti and V. Srinivasan
Dept. of Applied Mechanics, Indian Inst. of Tech., Madras, 600036, India, Shock Vib. Dig., 13 (7), pp 3-8 (July 1981) 72 refs

Key Words: Machine tools, Vibration isolation, Vibration damping, Chatter, Noise generation, Reviews

Analytical and experimental methods for assessing machine tool vibration are summarized, as are methods for dealing with vibration isolation, damping, chatter, and noise.

This workshop was held to summarize the current state of knowledge and to establish research needs on seismic aspects of highway bridge design. Main objects included the following: to evaluate current knowledge and practice in the planning, design, and construction of earthquake-resistant bridges; to examine needs and priorities for immediate and long-range research required to minimize gaps in current knowledge and improve current practice; and to improve communication and cooperation between research and professional organizations as well as among different research groups.

MATERIALS HANDLING EQUIPMENT

81-2308

Basic Research on the Vibratory Travelling Element (Travelling Mode and Velocity)

K. Sato, O. Kamada, N. Takatsu, and S. Moriya

Faculty of Engrg., Utsunoniya Univ., 2753, Ishiicho, Utsunomiya, 321, Bull JSME, 24 (189), pp 585-590 (Mar 1981) 13 figs, 3 refs

Key Words: Oscillating conveyors, Materials handling equipment

A new type of oscillating conveying is described. It uses a new traveling mechanism, termed a vibratory traveling element, which has two different inclinations and act on cantilever springs. First, the possibility of traveling is examined by means of computer simulation using a dynamical model, and secondly, the traveling mode and the velocity are investigated experimentally.

81-2310

Stochastic Control of Structures

M. Abdel-Rohman and H.H. Leipholz

Dept. of Civil Engrg., College of Engrg. and Petroleum, Kuwait Univ., P.O. Box 5969, Kuwait, ASCE J. Struc. Div., 107 (7), pp 1313-1325 (July 1981) 7 figs, 20 refs

Key Words: Bridges, Random vibration, Vibration control, Stochastic processes

The problem of how to control a structure against random disturbance of known statistical properties is investigated. An optimal control law can be found as a combination of closed-loop control and open-loop control. The open-loop control depends on the statistics of the disturbance, but the closed-loop control depends on the current response of the structure. The approach is used for controlling a sample span bridge against the effect of the irregularities of the bridge deck. The irregularities are assumed to be stationary random processes with known mean and variance. A comparison between the controlled and uncontrolled responses is considered.

STRUCTURAL SYSTEMS

BRIDGES

(Also see No. 2438)

81-2309

Earthquake Resistance of Highway Bridges, Proc. of a Workshop Held at San Diego, CA, Jan 29-31, 1979

R.L. Mayes and R.L. Sharpe

Applied Technology Council, Palo Alto, CA, Rept. No. NSF/RA-790387, 621 pp (Nov 1979) PB81-150591

Key Words: Bridges, Seismic design, Earthquakes, Proceedings

BUILDINGS

(Also see No. 2392)

81-2311

Dynamic Properties of Residential Structures Subjected to Blasting Vibrations

C.H. Dowding, P.D. Murray, and D.K. Atmatzidis

Dept. of Civil Engrg., Northwestern Univ., Evanston, IL 60201, ASCE J. Struc. Div., 107 (7), pp 1233-1249 (July 1981) 9 figs, 6 tables, 18 refs

Key Words: Buildings, Blast excitation, Mines (excavations), Seismic response

The responses of 23 single family residences to motions from surface mining blasts were analyzed with Fourier power spectral density and transfer functions to determine their dynamic response properties. The fundamental frequency of the structural frames, which had an average value of 7.0 Hz, decreased with increasing height of the structure. The damping of these structures was observed to increase with increasing induced absolute motions. These results apply directly to the study of the response of structures subject to ground motions from mining activities, and are also useful for the study of response to earthquakes.

FOUNDATIONS

(Also see No. 2504)

81-2312

Transient Response of an Elastic Half Space to Moving Loads

K. Watanabe

Dept. of Mech. Engrg. II, Tohoku Univ., Sendai, Japan, Bull. JSME, 24 (192), pp 913-919 (June 1981) 2 figs, 15 refs

Key Words: Elastic half-space

In this paper the transient response of an elastic half space to a non-uniformly moving point load is considered and a solution procedure is developed for the problem of moving loads.

81-2313

Seismic Analysis of Structures Embedded in Saturated Soils

R.H. Lung

Ph.D. Thesis, City Univ. of New York, 283 pp (1981) UM-8112759

Key Words: Interaction: soil-structure, Seismic analysis

The influence of pore water on the dynamic soil-structure interaction process has been studied. The equations of motion of the two phase soil/water system are presented and the corresponding finite element analogy developed. Numerical results have then been generated to determine the influence of pore water on the dynamic compliance coefficients typically used for seismic interaction studies. The results indicate that pore water significantly influences both the magnitude and character of these coefficients.

UNDERGROUND STRUCTURES

(See No. 2419)

HARBORS AND DAMS

(Also see No. 2317)

81-2314

Tsunamis -- Harbor Oscillations Induced by Nonlinear Transient Long Waves

T.G. Lepelletter

Ph.D. Thesis, California Inst. of Tech., 494 pp (1981) UM 8105159

Key Words: Harbors, Water waves, Hydrodynamic excitation

The process of excitation of harbors and bays by transient nonlinear long waves is investigated theoretically and experimentally. Nonlinear shallow water waves generated in a closed rectangular basin by the motion of the basin are also examined.

PRESSURE VESSELS

(See No. 2475)

POWER PLANTS

(Also see Nos. 2412, 2475)

81-2315

The Response of a Thermal Barrier System to Acoustic Excitation in a Gas Turbine Nuclear Reactor

W.S. Betts, Jr. and R.D. Blevins

General Atomic Co., San Diego, CA, ASME Paper No. 80-GT-16

Key Words: Nuclear reactor components, Acoustic excitation

This study examines the dynamic response of a thermal barrier configuration consisting of a fibrous insulation compressed against the reactor vessel by a coverplate which is held in position by a central attachment fixture. The results of dynamic vibration analyses indicate the effect of the plate size and curvature and the attachment size on the response of the thermal barrier.

81-2316

A Structural Priority Approach to Fluid-Structure Interaction Problems

M.K. Au-Yang and J.E. Galford

The Babcock & Wilcox Co., Nuclear Power Generation Div., Lynchburg, VA, J. Pressure Vessel Tech., Trans. ASME, 103 (2), pp 142-150 (May 1981) 8 figs, 2 tables, 8 refs

Key Words: Interaction: structure-fluid, Nuclear reactors

In a large class of dynamic problems occurring in nuclear reactor safety analysis, the forcing function is derived from the fluid enclosed within the structure itself. Since the structural displacement depends on the fluid pressure, which in turn depends on the structural boundaries, a rigorous approach to this class of problems involves simultaneous solution of the coupled fluid mechanics and structural dynamics equations with the structural response and the fluid pressure as unknowns. This paper offers an alternate approach to the foregoing problems. It is shown that for this kind of problem, the effect of fluid-structure interaction can be accounted for by a fluid mass matrix, which can be computed by the series expansion method.

OFF-SHORE STRUCTURES

81-2317

A Review of Hydrodynamic Load Analysis for Submerged Structures Excited by Earthquakes

R.E. Taylor

Dept. of Mech. Engrg., Univ. College London, Torrington Place, London WCIE 7JE, UK, Engrg. Struc., 3 (3), pp 131-139 (July 1981) 4 figs, 62 refs

Key Words: Submerged structures, Dams, Off-shore structures, Drilling platforms, Seismic design, Interaction: structure-fluid, Hydrodynamic excitation

Analysis of hydrodynamic loads on submerged structures is reviewed in the context of aseismic design of dams, intake towers and offshore platforms. The structures are considered to be flexible, and a linear fluid-structure interaction analysis is developed using the modes of vibration of a structure oscillating in the absence of a surrounding fluid. Particular attention is paid to the significance of fluid compressibility and free surface effects. As an illustration of the influence of these effects, a closed form solution and results are given for a simple rectangular reservoir-dam system. Numerical solutions are also discussed, based on finite element and boundary integral techniques for complex three-dimensional problems.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 2350, 2351, 2354, 2355, 2356, 2375, 2385, 2470, 2488, 2502)

81-2318

Reduction of Automobile Booming Noise Using Engine Mountings that Have an Auxiliary Vibrating System

H. Sakamoto, K. Yazaki, and M. Fukushima

Nissan Motor Co., Ltd., SAE Paper No. 810399

Key Words: Engine mounts, Automobile noise, Interior noise, Noise reduction

This paper presents a new concept concerning engine mountings that can reduce engine booming noise by utilizing an additional vector. Booming noise in passenger cars, particularly those with a four-cylinder engine, is caused by exciting forces such as the second harmonic of engine inertial force.

81-2319

Computerization of a Vehicle Pass-By Noise Measurement Facility

R.A. Bishop, T.F. Foxlee, and J.M. Strang

Ford Motor Co., Michigan Proving Ground, SAE Paper No. 810402

Key Words: Ground vehicles, Automobile noise, Noise source identification, Computer aided techniques, Fourier analysis, Data processing

A computerized data acquisition system for exterior vehicle noise testing was developed to provide the sophisticated data analysis techniques and test site efficiency required to meet current and future regulations. The computer generates accurate, dependable data in a final test report at the conclusion of each test minimizing data reduction and turnaround time. Computer control of test sequences eliminates manual operations and provides efficient use of site time. The inclusion of on line Fourier Analysis Techniques provides additional noise source identification capabilities.

81-2320
An Evaluation of Light Vehicle Exterior Noise Test Procedures
R.H. Paddy
Ford Motor Co., SAE Paper No. 810400

Key Words: Automobile noise, Noise measurement, Measurement techniques

This paper reviews the evaluation of four light vehicle exterior noise test procedures. Vehicle test results from two part throttle and one multi mode test are compared to the results from a currently in use wide open throttle procedure SAE J986. Each procedure is evaluated for clarity of instructions, time to test requirements, equipment requirements, vehicle changes required for the test, sound levels produced, how the procedures rank vehicles and the sources of sound.

81-2321
Automotive Applications of Three-Dimensional Acoustic Finite Elements
S.H. Sung
Engrg. Mechanics Dept., General Motors Res. Lab., General Motors Technical Ctr., SAE Paper No. 810397

Key Words: Automobile noise, Interior noise, Cavity resonators, NASTRAN (computer programs), Computer programs, Finite element technique

Three-dimensional acoustic finite elements have been applied to calculate the 'knock-induced' cavity resonances for combustion chambers and the cavity 'booming' frequencies for passenger compartments. The NASTRAN finite element program is employed to solve the acoustic free-vibration problems, and resonant frequencies obtained from these numerical predictions have been compared with experimental results. In addition, the resonant mode shapes are shown and illustrate the acoustic pressure distributions and nodal surfaces for particular resonant frequencies.

81-2322
Computer-Aided Techniques Used to Solve Vehicle Ride Problem
E.C. Peterson and J. Knobelock
Structural Dynamics Res. Corp., Milford, OH, TEST, 43 (3), pp 8-11 (June-July 1981) 8 figs

Key Words: Automobiles, Vibration analysis, Computer aided techniques

A procedure for the determination of a severe vibration problem of a newly designed car that occurred under certain operating conditions is presented. It consists of the determination of the frequency of vibration and input forces, studying the troublesome frequencies in the controlled environment of the test lab, determining the cause of the 15.7 Hz resonance, and developing a modal data base for solving the problem by means of a minicomputer system simulation software.

81-2323
Analytical Study on Engine Vibration Transfer Characteristics Using Single-Shot Combustion
Y. Hayashi, K. Sugihara, A. Toda, and Y. Ushijima
Nissan Motor Co., Ltd., Yokosuka, Japan, SAE Paper No. 810403

Key Words: Engine vibration, Combustion noise, Noise generation

In order to demonstrate the generation mechanism of "combustion noise" separately from "mechanical noise," the process of transfer in which vibration travels to each engine portion was analyzed. The effect of the natural frequency of each portion of the engine on the vibration transfer characteristics is discussed by introducing a vibration transfer function. The transfer paths of exciting forces which are caused by the combustion are quantitatively clarified.

81-2324
Measurement of Noise Inside Truck Cabins
A. Behar
Ontario Hydro, 757 McKay Rd., Pickering, Ontario L1W 3C8, Canada, Appl. Acoust., 14 (3), pp 215-223 (May-June 1981) 6 tables, 6 refs

Key Words: Trucks, Interior noise, Noise measurement, Standards and codes

The measurement of noise inside truck cabins presents a series of problems due to several factors such as changes in the vehicle's speed, changes in the external environment, variation in the noise level with the microphone location inside the cabin, and the window condition (open or closed). This paper discusses the only existing American standard on the subject and presents guidelines for another, more comprehensive standard, which takes into account several of the variables mentioned above. A real-life situation where those guidelines were applied is described and the results discussed.

81-2325

The Use of Acoustic-Intensity Scans for Sound Power Measurement and for Noise Source Identification in Surface Transportation Vehicles

J. Pope, R. Hickling, D.A. Feldmaier, and D.A. Blaser
Engrg. Mechanics Dept., General Motors Res. Lab., Warren, MI, Sae Paper No. 810401

Key Words: Trucks, Locomotives, Diesel engines, Sound power level, Noise source identification, Experimental test data

The results are reported of near-field, acoustic-intensity scans of a diesel-engine truck, chassis-mounted passenger-car engines, and a railroad locomotive. The measurements were made using the two-microphone, cross-spectral method of measuring acoustic intensity developed at General Motors. The results demonstrate the value of the method for measuring the overall sound power of a vehicle as well as for identifying its component noise sources. A review of theory and methodology is provided.

81-2326

Van Crashworthiness and Aggressivity Study

S. Davis and S. Peirce
Dynamic Science, Inc., SAE Paper No. 810090

Key Words: Ground vehicles, Vans, Collision research (automotive), Crashworthiness, Experimental test data

This paper presents the results of a series of van crash tests which were conducted by Dynamic Science, Inc. under contract to the National Highway Traffic Safety Administration (NHTSA). Six van tests were conducted against a unique load-measuring barrier to study the crashworthiness and aggressivity of two typical van models at speeds of 15, 25, and 30 mph. Two additional tests were conducted between each of the two van models and a typical fullsize passenger car.

81-2327

Influence of Lateral Restraint on Occupant Interaction with a Shoulder Belt or Preinflated Air Bag in Oblique Impacts

C.C. Culver and D.C. Viano
Biomedical Science Dept., General Motors Res. Lab., Warren, MI, SAE Paper No. 810370

Key Words: Collision research (automotive), Safety restraint systems, Seat belts, Air bags (safety restraint systems)

Sled tests were conducted at farside oblique angles of 15°, 45°, and 75° with a Part 572 dummy restrained by a conventional driver lap/shoulder belt system or a preinflated driver inflatable restraint. Occupant dynamics were compared in similar tests where an inboard energy absorbing lateral restraint of the upper torso was or was not used.

81-2328

Experimental Investigation of Crash Barriers for Measuring Vehicle Aggressiveness-Fixed Rigid Barrier Initial Results

R.A. Saul, T.F. MacLaughlin, C.L. Ragland, Jr., and D. Cohen
Vehicle Res. and Test Ctr., East Liberty, OH, SAE Paper No. 810093

Key Words: Collision research (automotive), Testing techniques

This paper presents the initial results of a crash test program designed to evaluate the ability of three different barriers to measure vehicle aggressiveness. The barriers included in the study are the fixed rigid (FRB), load cell fixed (LCFB) and moving deformable (MDB). Previous crash tests and analytical studies conducted to determine causes of aggressiveness and ways of measuring aggressiveness are reviewed. In this paper, full frontal car-to-car and FRB crash test results of an aggressive and a non-aggressive car are presented and compared.

81-2329

Static-to-Dynamic Amplification Factors for Use in Lumped-Mass Vehicle Crash Models

P. Prasad and A.J. Padgaonkar
Ford Motor Co., SAE Paper No. 810475

Key Words: Ground vehicles, Collision research (automotive), Lumped parameter method

One-dimensional, lumped-mass models for predicting the dynamic response of vehicles in crashes have been used extensively in recent years. The energy-absorbing characteristics, i.e., the load/deflection data, for use in the models are determined from static crusher tests of actual vehicle components. In order to account for the crush rate effects on the structure, a transformation is needed to extrapolate the statically obtained data to the dynamic case. The transformation factors – the static-to-dynamic amplification factors – are empirically derived and have been reported by some investigators to be linearly and by others to be loga-

rithmically related to crush rate. This paper reports on the development of dynamic amplification factors for vehicles with framed structures, e.g., light trucks and S-framed cars, and unibody cars.

81-2330

Derivation and Application of Restraint Survival Distance in Motor Vehicle Collisions

T.F. MacLaughlin
Vehicle Res. and Test Ctr., National Highway Traffic Safety Admn., U.S. Dept. of Transportation, East Liberty, OH, SAE Paper No. 810092

Key Words: Collision research (automotive), Safety restraint systems

Restraint Survival Distance (RSD), a quantity used for determining potential occupant survival in a motor vehicle collision, is derived. The RSD depends upon the vehicle crash response, available occupant stroking distance (taking compartment intrusion into account) and assumptions regarding ideal restraint system performance. RSD calculations were performed for 17 passenger cars which were subjected to 30 mph barrier crash tests. The RSD values were compared with measured dummy responses. Similarities and differences between actual crashsurvivability levels achieved with existing restraint systems and potential crashsurvivability levels achievable with ideal restraint system characteristics were explored.

81-2331

Lateral Dynamics of a Rail Transit Vehicle: A Comprison of Experimental and Theoretical Results

J.A. Young and T.A.P.S. AppaRao
Transport & Vehicle Systems Office, Res. & Dev. Branch, Ontario Ministry of Transportation and Communications, Ontario M3M 1J8, Canada, J. Dyn. Syst., Meas. and Control, Trans. ASME, 103 (1), pp 39-48 (Mar 1981) 13 figs, 3 tables, 20 refs

Key Words: Railroad trains, Subway cars, Lateral response, Cornering effects

A subway rail vehicle was tested on tangent and curved track sections to provide dynamics data for validation of theoretical models. Tests were done with three combinations of primary suspension and wheel profiles which were selected using a simplified truck stability/curving tradeoff analysis. The test results of one configuration are compared with two lateral dynamic models. Experimental frequency and damping results are compared with the predictions of a linear Lateral Stability model for a number of vehicle speeds. The measured time histories of vehicle responses on a spiral and a 122 m (400 ft) radius curve are compared with the results obtained from a Curve Entry Dynamics model. The agreement between theory and experiment varied from good to poor depending on the parameter being compared. The discrepancies between theory and experiment can be attributed to four major sources: limitations of models, errors in vehicle parameters used in obtaining theoretical results, measurement errors and data analysis limitations.

81-2332

Study on the Mechanism of Train Noise and Its Countermeasure (Part III, Wheel Flexural Vibration Including the Effects of Shear Deformation and Rotatory Inertia)

H. Matsuhisa, Y. Honda, and S. Sato
Faculty of Engrg., Kyoto Univ., Sakyo-ku, Kyoto, Japan, Bull. JSME, 24 (191), pp 849-853 (May 1981) 5 figs, 2 tables, 3 refs

Key Words: Interaction: rail-wheel, Plates, Circular plates, Variable cross section, Transverse shear deformation effects, Rotatory inertia effects, Noise generation, Flexural vibration

Train noise is dominated by the wheel flexural vibration which is caused by interactions between wheel and rail. Since the wheel is remarkably thick, the flexural vibration cannot be analyzed on the assumption that the wheel is a thin circular plate. The effects of shear deformation and rotatory inertia should be taken into consideration. The wheels which are used in Japanese rapid transit (Shinkansen) trains may be assumed to be a circular plate with stepped thickness. In this paper, the vibration is theoretically analyzed with due regard to the above facts, and the results are compared with the experimental ones. All results are in significant accordance, and some interesting characteristics are obtained.

SHIPS

(Also see No. 2381)

81-2333

Hydro-Acoustics of a Cavitating Screw Propeller; Far-Field Approximations

L. Noordzij and J. van der Kooij

VEG-Gasinstituut, Apeldoorn, The Netherlands, J. Ship Res., 25 (2), pp 90-94 (June 1981) 3 figs, 8 refs

Key Words: *Marine propellers, Noise generation*

To predict the far-field radiated noise of a cavitating screw propeller, acoustic tests have to be performed on model scale. In this paper the far-field approximation of the sound pressure of the cavitating screw propeller is derived. The conditions for which the sound pressure, as obtained on model scale, can be considered to be the far-field sound pressure, and the resulting frequency range, are discussed.

81-2334

An Analysis of the Quadratic Frequency Response for Lateral Drifting Force and Moment

C.H. Kim and J.F. Dalzell

Davidson Lab., Stevens Inst. of Technology, Hoboken, NJ, J. Ship. Res., 25 (2), pp 117-129 (June 1981) 6 figs, 2 tables, 22 refs

Key Words: *Ships, Water waves, Frequency response function*

Results of calculations are given for lateral drifting forces acting on a cylinder and a Series 60 hull derived by a new procedure involving application of the quadratic frequency response function (QFRF) and the close-fit method for flows induced by hull sections in the near field. The near-field solutions are required by the QFRF in order to obtain the nonlinear (second order) interaction effects in the presence of dual waves. This method yields the mean drifting force consisting of four components of which the relative-wave-elevation term is dominant, whereas the Bernoulli quadratic term is secondary. A mathematical discontinuity of the drifting force in the neighborhood of a high frequency is investigated by applying a modified Green's function.

81-2335

Nonlinear Analysis of Slow Drift Oscillations of Moored Vessels in Random Seas

J.B. Roberts

School of Engrg. and Applied Sciences, Univ. of Sussex, Falmer, Brighton, Sussex, UK, J. Ship Res., 25 (2), pp 130-140 (June 1981) 13 figs, 24 refs

Key Words: Ships, Moorings, Water waves

A theoretical model is proposed for a moored vessel, with nonlinear restoring forces, responding to random waves. The model takes into account the nonlinear nature of the relationship between wave elevations and wave forces. Fokker-Planck equations are derived for the distribution of the amplitude response of the vessel. By simplifying these equations, with the introduction of a white noise approximation for the force process, an expression is obtained for the stationary amplitude distribution. The accuracy of this approximate result is assessed by a comparison with corresponding digital simulation estimates.

81-2336

A Mathematical Model for the Prediction of Impact Force Due to Ship Collision

P.Y. Chang and C. Thasanatorn

Hydronautics, Inc., Laurel, MD, Rept. No. TR-7923-1, MA-RD-940-80076A, 187 pp (May 1980) PB81-151599

Key Words: Collision research (ships), Mathematical models

A mathematical model for the prediction of collision impact force has been developed. The model is a synthesis of the collapse theorems, analytical methods for structural mechanics, and experimental data. This model has been validated by simulation of the bow models in the GKSS collision tests. It is also applied to the prediction of the collapse load of the bow of the U.S.C.G. icebreaker POLAR STAR.

AIRCRAFT

(Also see No. 2357)

81-2337

Current Status and the Future of Advanced Supersonic Transport Noise

J.V. O'Keefe, R.A. Mangiarotty, and N. Pickup

Boeing Commerical Airplane Co., Seattle, WA, J. Aircraft, 18 (7), pp 576-581 (July 1981) 16 figs, 1 table, 11 refs

Key Words: Aircraft noise, Noise reduction

Noise-control technology developed during the past decade could enable the United States to resume development of an advanced supersonic transport (SST) that will give acceptable levels of noise. Such developments include coannular and nonconcentric nozzles, thermal acoustic shields, and mechanical suppressors to control jet noise, the primary source of SST noise. Advanced operational procedures during takeoff and landing will reduce SST community noise. How-

ever, because the success of noise-suppression devices cannot be predicted with certainty, more noise-control technology must be developed and flight tested to ensure that SST jet and turbomachinery noise can meet community-noise standards of the future.

81-2338

Noise Transmission and Control for a Light Twin-Engine Aircraft

C.K. Barton and J.S. Mixson

NASA Langley Research Ctr., Hampton, VA, J. Aircraft, 18 (7), pp 570-575 (July 1981) 17 figs, 1 table, 9 refs

Key Words: Aircraft noise, Noise reduction, Noise transmission

One of the dominant source-path combinations for cabin noise in light twin-engine aircraft is propeller noise being transmitted through the fuselage sidewall. This source-path was investigated and candidate sidewall add-on treatments were installed and tested using both an external sound source and the propeller in ground static engine runs. Results indicate that adding either mass or stiffness to the fuselage skin would improve sidewall attenuation and that the honeycomb stiffness treatment provided more improvement at most frequencies than an equal amount of added mass.

81-2339

Nonlinear Propagation of Aircraft Noise in the Atmosphere

C.L. Morfey and G.P. Howell

The Univ. of Southampton, Southampton, UK, AIAA J., 19 (8), pp 986-992 (Aug 1981) 10 figs, 1 table, 23 refs

Key Words: Aircraft noise, Sound propagation

Carefully controlled tests of aircraft noise propagation have shown instances of anomalously low attenuation (deficiencies in excess of 10 dB over 500 m) for frequencies in the range 5-10 kHz. These results have been explained with the aid of a statistical theory of finite-amplitude noise propagation. Detailed analysis of recordings from one test has provided a direct check on the nonlinear theory. Results from several different tests have been incorporated in a statistical model, which allows the nonlinear distortion of aircraft noise spectra to be estimated as a function of distance, level, spectrum shape, and atmospheric conditions. Preliminary results show encouraging agreement with the anomalous data.

81-2340

Helicopter Rotor Thickness Noise

C. Dahan and E. Gratieux

Office National d'Etudes et de Recherches Aerospatiales, Chatillon, France, J. Aircraft, 18 (6), pp 487-494 (June 1981) 15 figs, 11 refs

Key Words: Propeller blades, Geometric effects, Noise generation

Attention is focused on rotor blade thickness noise. The solution of the wave equation is written in a closed form (frequency domain) which emphasizes the essential parameters for this field. From an estimation of the loads on the rotor disk (lifting-line theory), the acoustic emission due to loads is estimated in such a way that the acoustic efficiency of blade thickness and loads is compared. To compare experimental results and predictions, an original signal processing method was designed, which compensates the Doppler effect due to the helicopter motion.

81-2341

Propeller Light Aircraft Noise at Discrete Frequencies

C. Dahan, L. Avezard, G. Guillien, C. Malarmey, and J. Chombard

Office National d'Etudes et de Recherches Aerospatiales, Chatillon, France, J. Aircraft, 18 (6), pp 480-486 (June 1981) 17 figs, 9 refs

Key Words: Aircraft noise, Propeller noise, Noise measurement

In-flight measurements are analyzed to study the acoustic field of a propeller-driven light aircraft. The separation of noise sources is achieved by examination of the influence on the acoustic field of the propeller and the engine. At high rotational speed, the propeller is the dominant source. Evaluating the field due to steady/unsteady loading on the blades, one concludes that the former are acoustically the most efficient. The analysis of flyover noise measurements, using an original signal processing (Dopper effect compensation) enhances the results.

81-2342

NOISECHECK Procedures for Measuring Noise Exposure from Aircraft Operations

D.E. Bishop, A.S. Harris, J. Mahoney, and P.E. Rentz

Bolt, Beranek and Newman, Inc., Cambridge, MA,

Rept. No. BBN-3869, AFAMRL-TR-80-45, 107 pp (Nov 1980)
AD-A093 948

Key Words: Aircraft noise, Noise measurement, Computer programs

NOISECHECK is a measurement program used when an engineer is uncertain about a sound exposure level (SEL) resulting from a particular type of operation or to check noise contours determined by NOISEMAP - an Air Force computer program. The file of aircraft noise data used by NOISEMAP is called NOISEFILE. The NOISECHECK measurement program uses portable noise monitors that measure day-night sound levels (DNLs) over one or more days as well as individual sound exposure levels (SELs). The measured DNLs are then compared with the DNLs calculated by NOISEMAP, or they contribute SEL data for comparison with NOISEFILE. This report delineates the field test data acquisition and analysis procedures used to conduct NOISECHECK type measurement studies. A companion report describes the instrumentation development and subsequent field test conducted at Barksdale AFB as part of this research effort.

81-2343
Sonic Fatigue Design Data for Bonded Aluminum Aircraft Structures
M.J. Jacobson
Northrop Corp., Hawthorne, CA, J. Aircraft, 18 (6), pp 438-444 (June 1981) 9 figs, 5 tables, 10 refs

Key Words: Acoustic fatigue, Aircraft, Fatigue tests, Bonded structures, Panels, Aluminum

A combined analytical and experimental program was conducted to determine sonic fatigue design properties of bonded structural sections commonly used in aircraft and to formulate data and criteria for the development of sonic fatigue designs of such structure. An objective of the program was to develop information applicable to aircraft fuselage panels using adhesive bonding in the primary structure, in lieu of mechanical fasteners such as are currently used. Ten flat, rectangular, acoustic test panels featuring the FM73/BR127 adhesive system, a phosphoric acid anodizing process, and 7075-T6 aluminum alloy skin and substructure were designed and fabricated. Panel tests were conducted under broadband acoustic excitation. In preliminary testing, nonlinear strain-pressure relationships were observed and natural frequencies increased with sound pressure level. Subsequently, sonic fatigue tests were conducted at a constant overall sound pressure level.

81-2344
Experimental Substantiation for Hovering Rotor Vertical Impedance Calculations
K. Kato, T. Yamane, T. Nagashima, N. Iboshi, and K. Yamagishi
Univ. of Tokyo, Tokyo, Japan, J. Aircraft, 18 (6), pp 445-450 (June 1981) 16 figs, 2 tables, 15 refs

Key Words: Propeller blades, Mechanical impedance, Experimental test data

An experiment using a model rotor was conducted to ascertain the accuracy of theoretical impedance calculations. A two-bladed balsa rotor of 1.2 m diam was constructed with a force-sensing device integrated within the hub. The apparatus was so designed that the rotor could perform forced vertical oscillations of varying frequencies, and the resulting hub vertical loads were measured in the nonrotating frame. The conclusions obtained after correlation of the measured and theoretical results were that the quasisteady aerodynamic assumption determines only the rough trend of these impedance characteristics and that a typical section aerodynamic analysis using Loewy's lift deficiency function can predict impedance peaks and clefts occurring near the multiples of the blade passage frequencies due to the preceding and returning wakes.

81-2345
A Study of the Effects of Store Aerodynamics on Wing/Store Flutter
C.D. Turner
Ph.D. Thesis, Virginia Polytechnic Inst. and State Univ., 83 pp (1980)
UM 8110479

Key Words: Aircraft, Wing stores, Flutter

This study represents the first systematic analytical study of the effect of store aerodynamics on wing/store flutter. A large number of wing/store single carriage configurations and parameters were included in the study; multivariate analysis techniques were used for the first time to analyze wing/store configurations, modal data, and flutter results.

MISSILES AND SPACECRAFT
(Also see No. 2291)

81-2346
Flexible Spacecraft Attitude Control Using a Simple P + D Algorithm
J. Fenton and K.F. Gill

Dept. of Mech. Engrg., Univ. of Leeds, Aeronaut. J., 85 (844), pp 185-189 (May 1981) 5 figs, 9 refs

Key Words: Spacecraft, Control equipment

The results of this work show that a control algorithm utilizing attitude positions and derived rates can provide adequate attitude control and regulation of flexural motion, comparable with that obtained from full state vector feedback, if measurement noise can be suppressed. If measured rates are available for use in the control scheme the measurement noise loses its importance and more stringent control is possible. The control algorithm is robust and will tolerate a high degree of process mismatch. Preliminary knowledge of the pole positions for acceptable control can be found by means of the Klienman stabilizing algorithm to avoid solution of the Riccati equation at the early stages of design.

81-2347
Vibration of Immiscible Liquids in Rotating Cylinders (Schwingungen nichtmischbarer Flussigkeiten im rotierenden Kreiszylinder)
H.F. Bauer
Z. angew. Math. Mech., 60 (12), pp 653-661 (Dec 1980) 5 figs, 8 refs
(In German)

Key Words: Spacecraft, Rotating structures, Containers, Fluid filled containers, Fluids, Natural frequencies

Spin stabilized satellites are easily susceptible to nutational vibrations, which endanger mission and proper operation of a satellite considerably. Nutational dampers enhance such an operation. For the design of such a nutational damper knowledge of the liquid behavior in a rotating infinitely long cylindrical container completely or partially filled with immiscible, incompressible and nonviscous liquids is required. The natural frequencies, as well as the response of the liquid to forced container excitation, is presented.

81-2348
Slosh Dynamics of a Spin-Stabilized Space-craft Comprising Off-Axis Tanks Filled Partially with Liquid Propellant
L.L. Fontenot
Jet Propulsion Lab., Pasadena, CA, Rept. No. NASA-CR-164004, JPL-PUB-80-97, 56 pp (Feb 15, 1981) N81-18085

Key Words: Tanks (containers), Fluid-filled containers, Sloshing, Rotating structures, Spacecraft

The fundamental nonlinear equations of motion were derived and specialized to a steady-state rotation of the vehicle about a given axis of rotation. A thrust about the spin axis was introduced. A perturbation solution was derived which linearizes the problem. The effect of the centrifugal and coriolis accelerations together with vorticity are implicitly taken into consideration in the formulation. A variational formulation of the associated boundary conditions is presented. For practical cases it is shown that the simple classical pendulum representation for slosh is not very appealing for a spinning spacecraft unless severe restrictions are allowed.

BIOLOGICAL SYSTEMS

HUMAN

(Also see No. 2452)

81-2349
Perception, Comfort and Performance Criteria for Human Beings Exposed to Whole Body Pure Yaw Vibration and Vibration Containing Yaw and Translational Components
A.W. Irwin
Dept. of Civil Engrg., Heriot-Watt Univ., Riccarton, Edinburgh EH14 4AS, UK, J. Sound Vib., 76 (4), pp 481-497 (June 22, 1981) 11 figs, 1 table, 21 refs

Key Words: Vibration excitation, Human response

Human perception thresholds, in both the presence and the absence of visual cues, and equal sensation contours for low frequency whole body pure yaw vibration were investigated. The results from these and other laboratory tests were combined with field test data for the human response to predominantly yaw vibration, caused by rotational oscillations of civil structures about a vertical axis of the human subjects, to provide guidelines for probable human response to pure yaw vibration at different levels in a variety of circumstances. Relationships have also been derived to allow assessment of the probable responses of occupants of fixed structures to motion which exposes them to the more common case of simultaneous yaw and horizontal translational components of vibration.

81-2350
Truck Ride Quality and Drivers' Health: An Assessment
T.J. Naughton, Jr. and R.D. Pepler
Dunlap and Associates, Inc., SAE Paper No. 810044

Key Words: Trucks, Ride dynamics, Human response

The state-of-the-art with respect to the health effects of long term exposure to whole-body shock and vibration is reviewed. The epidemiological and data availability problems of conducting definitive research into the relationship between long-term exposure to shock and vibration and the health of truck drivers are analyzed and requirements for a feasible, scientifically sound epidemiological research program that can be implemented incrementally are described.

81-2351
Subjective and Objective Ride Evaluations of Commercial Vehicles
N.C. Mehta
International Harvester Co., SAE Paper No. 810046

Key Words: Ride dynamics, Ground vehicles, Vibration analysis, Human response

The purpose of this paper is to explore the degree of correlation between the subjective ride evaluations by a qualified group of people and various objective ride vibration analysis techniques. It is not the purpose of this paper to establish limits to acceptable levels of vibration or vibration comfort criteria on an absolute basis. Rather it deals with relative aspects of ride comparisons between various vehicles. Preliminary evaluations of these objective techniques indicate that they correlate well with subjective evaluations.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

81-2352
Material and Design Interactions in Collision Energy Management
B.S. Levy
Inland Steel Co., SAE Paper No. 810234

Key Words: Energy absorption, Steel

Conventional analysis of energy management works with force, velocity, vehicle mass, and time. The purpose of this paper is to view energy management by analyzing how the material in the structure absorbs energy. To supplement the analysis, strain rate sensitivity data on a variety of mild and high-strength cold-rolled steels are presented and the implications of the results analyzed. Other results from the literature are also discussed.

81-2353
Experimental Determination and Practical Application of the Four-Pole Parameters of Structure-Borne Sound Isolators
G. Meltzer and R. Melzig-Thiel
Zentralinstitut f. Arbeitschutz DDR, 8020 Dresden, Gerhart-Hauptmann-Strasse, Arch. Accustics, 5 (4), pp 315-336 (1980) 18 figs, 10 refs

Key Words: Acoustic insulation, Vibration isolators, Structure-borne noise

Theoretical fundamentals are derived for measuring the four-pole parameters of vibration isolators at real loads. Since the dynamic properties of rubber springs depend on the initial load, the vibration force and velocity are measured on the isolator interfaces for a given initial load. Four-pole parameters are determined for rubber springs and steel springs. The frequency characteristics of the parameters, calculated from the measured results, are compared with the theoretical frequency characteristics. Furthermore, approximate relations for the determination of the four-pole parameters are derived, and verified by experiments. Practical application of the four-pole parameters of vibration isolators is illustrated by examples in which calculations are performed for structure-borne sound wave isolation by longitudinally vibrating continua and the excitation of structure-borne sound by machines.

81-2354
Crush Strength Analysis of Lightweight Vehicle Frame Components
C.M. Ni
Engrg. Mechanics Dept., General Motors Res. Lab., Warren, MI, SAE Paper No. 810232

Key Words: Collision research (automotive), Energy absorption, Steel, Aluminum, Fiber composites

An analytical technique is presented in this paper to analyze the crush strength (or force-deflection curve) of lightweight vehicle frame components which are made of high-strength steel, aluminum alloy, and fiber-reinforced composite. Experimental data are also included.

81-2355

Energy Absorption of Glass Polyester Structures

P.A. Kirsch and H.A. Jahnle
The Budd Co. Technical Center, SAE Paper No. 810233

Key Words: Collision research (automotive), Energy absorption, Reinforced structures, Glass reinforced plastics, Fiber composites

This study, conducted in two parts, was directed toward the characterization of glass fiber reinforced polyesters (GFRP) and their ability to absorb crash energy. The first part of the study entailed evaluating the crushing characteristics of various hand lay-up and commercially available GFRP samples. The second part of the study used compression molded low profile sheet molding compound material for the crushing samples. Evaluation of foam filled samples was also performed in each half of the study.

81-2356

Computer Optimization of Trailer Suspensions

D.E. Egbert and A. Linlecki
San Jose State Univ., San Jose, CA 95112, Mech. Mach. Theory, 16 (4), pp 369-384 (1981) 3 figs, 2 tables, 11 refs

Key Words: Suspension systems (vehicles), Trailers, Computer aided techniques, Design techniques

An optimization procedure which has been developed to select appropriate suspension design parameters for a simple two wheel trailer is presented. A modern approach to the optimization problem has been used applying non-linear programming to the constrained search for the minimum of an objective function. The acceleration response to roadway input of selected points on the load of the trailer has been designated for minimization. This acceleration has an important significance to the trailer design because of its effect on the stable and smooth ride of the trailer. Two computational procedures have been used and the results compared. The first approach involves the linear superposition of responses to a series of discrete sinusoidal inputs while the second applies more contemporary random vibration theory using power spectral density curves to simulate the actual road surfaces. The results of the optimization procedure are then compared with the response characteristics of the original trailer design and demonstrate that a substantial improvement has been made.

81-2357

Recent Development of the YF-17 Active Flutter Suppression System

C. Hwang, E.H. Johnson, and W.S. Pi
Northrop Corp., Hawthorne, CA, J. Aircraft, 18 (7), pp 537-545 (July 1981) 19 figs, 2 tables, 3 refs

Key Words: Aircraft, Wing stores, Active flutter control

Active wing/store flutter suppression systems were demonstrated in 1977 in a series of wind tunnel tests on a YF-17 scale model. In order to substantially improve the suppression system performance, new control laws were developed based on multiple feedback loops, multiple control surfaces, or both. For test safety, a flutter sensing unit and a new store, functioning as a flutter stopper, were designed and fabricated. Test monitoring programs were organized on a Hewlett-Packard 5451C Fourier Analyzer that permitted a real time assessment of the control law effectiveness. One of the monitoring programs generated the aircraft open loop transfer function and Nyquist plots in the supercritical region while the flutter suppression loop was closed. In the tests performed in late 1979, the new control laws were applied to suppress a severe flutter condition to 70% above the uncontrolled flutter dynamic pressure. Postanalysis of the test data indicated the potential to increase the dynamic pressure to an even higher level.

SPRINGS

81-2358

Design Nomographs of Compression Helical Springs for Predetermined Reliability Levels

M.D. Thien and M. Massoud
Mech. Engrg. Dept., Ecole de Technologie Superieure, Univ. of Quebec, Montreal, Canada, J. Mech. Des., Trans. ASME, 103 (2), pp 268-273 (Apr 1981) 7 figs, 1 table, 14 refs

Key Words: Springs, Helical springs, Periodic excitation, Axial excitation, Design techniques, Nomographs, Probability theory

This paper discusses a probabilistic approach for the design of compression closely coiled helical springs subjected to periodic axial loading. The classical design procedure results in deterministic geometric parameters with tolerances normally chosen according to standards without due regard to their effects on the mission success as normally expressed by a reliability level. With the proposed design procedure, the engineer can specify nominal mean values for the geometric parameters and their tolerances according to a predetermined reliability level. Design nomographs are presented to help the engineer, in the early stages of design, to choose between many alternatives.

TIRES AND WHEELS

81-2359
Instrumented Approaches to Ride Comfort from the Perspective of Tire Engineers
S.A. Lippmann and K.L. Oblizajek
Uniroyal Tire Co., SAE Paper No. 810063

Key Words: Tires, Ride dynamics, Measurement techniques

The paper has two objectives: to describe the manner in which tires are involved in the "torsional nibble" disturbance, an occasional problem in vehicle development; and to illustrate a generally applicable approach for diagnosing the relationships between tire properties and subjective disturbances.

BLADES

81-2360
Flutter Spectral Measurements Using Stationary Pressure Transducers
A.P. Kurkov
NASA Lewis Res. Ctr., Cleveland, OH 44135, J. Engrg. Power, Trans. ASME, 103 (2), pp 461-467 (Apr 1981) 12 figs, 3 tables, 11 refs

Key Words: Blades, Rotors, Flutter, Measurement techniques, Transducers

Engine-order sampling was used to eliminate the integral harmonics from the flutter spectra corresponding to a case-mounted static pressure transducer. From the optical displacement data it was demonstrated that blade-order sampling of pressure data can yield erroneous results because of the interference caused by blade vibration. Two methods are presented that effectively eliminate this interference and yield the blade-pressure-difference spectra. The phase difference between the differential-pressure and displacement spectra was evaluated.

81-2361
Rotating Blade Vibration Analysis Using Shells
A.W. Leissa, J.K. Lee, and A.J. Wang
Ohio State Univ., Columbus, OH, ASME Paper No. 81-GT-80

Key Words: Blades, Turbomachinery blades, Rotating structures, Shells, Ritz method, Natural frequencies, Mode shapes

Shallow shell theory and the Ritz method are employed to determine the frequencies and mode shapes of turbomachinery blades having both camber and twist, rotating with nonzero angles of attack. Frequencies obtained for different degrees of shallowness and thickness are compared with results available in the literature, obtained from finite element analyses of nonrotating blades.

81-2362
A Coincidence Criterion for Effective Sound Radiation from a Resonant Free Running Circular Saw Blade
U.R. Kristiansen
Acoustics Lab., Univ. of Trondheim, N-7034 Trondheim-NTH, Norway, Appl. Acoust., 14 (4), pp 267-280 (July-Aug 1981) 7 figs, 8 refs

Key Words: Disks (shapes), Blades, Circular saws, Saws, Sound generation

A study has been made of the pure tone noise emitted from spinning circular discs vibrating in modes with nodal diameters only. The main application is idling circular saw blades at high speeds. It is shown that above a certain rotational speed, which again is a function of the material parameters and the geometry, a disc will have a high radiation efficiency and therefore be an effective radiator of sound.

81-2363
Blade Excitation by Elliptical Whirling in Viscous-Damped Jet Engines
N. Klompas
Gas Turbine Div., General Electric Co., 1 River Rd., Schenectady, NY 12345, J. Engrg. Power, Trans. ASME, 103 (2), pp 326-330 (Apr 1981) 7 figs, 5 refs

Key Words: Turbine blades, Blades, Failure analysis, Whirling, Disks (shapes)

An extension of the author's earlier method of analyzing multi-shaft jet engine dynamics accounting for flexibility of bladed disks is outlined to calculate the first whirl harmonic for given nonlinear characteristics of squeeze-film dampers. A second whirl harmonic, of which experimental verification is found in Campbell's paper of 1924, is shown induced by orbit ellipticity. The possibility that this harmonic, especially due to backward whirling, may be a source of blade

excitation at higher frequencies than currently recognized from linear analysis is discussed by relating some engine experience.

81-2364

Unsteady Responses and Wake Energy of Turbine Rotor Cascade to Sinusoidal Gust

T. Nishiyama and M. Yanome

Faculty of Engrg., Tohoku Univ., Senai, Japan, Tohoku Univ., Tech. Reports, 45 (2) (1980) 15 figs, 13 refs

Key Words: Rotor blades (turbomachinery), Blades, Fluid-induced excitation

This paper aims at developing a higher accuracy method of analysis for dynamic responses of turbine rotor blades to sinusoidal gust under the basic assumptions: the unsteady perturbations are of small order and, on the other hand, the steady ones of finite order in magnitude; the viscous wakes from upstream stator are regarded as the sinusoidal gust in potential flow and then transported by the local steady perturbed velocity within the cascade passage and on the aft stagnation streamline from the trailing edge. Numerical calculations are made to clarify some essential features of the unsteady pressure distributions, unsteady forces and the energy loss by wake vortex on turbine rotor blade of reaction and impulse types.

BEARINGS

81-2365

Analysis of Self-Acting, Gas-Lubricated Journal Bearings

S. Murata, Y. Miyake, and N. Kawabata

Faculty of Engrg., Osaka Univ., Yamada-kami, Suita, Osaka, Japan, Bull. JSME, 24 (191), pp 854-862 (May 1981) 14 figs, 7 refs

Key Words: Bearings, Journal bearings

A method to solve exactly the flow of a fluid film of self-acting gas-lubricated journal bearings and an approximate method using transformation of variable which renders the basic equation quasi-linear are presented. The analysis is conducted for static and dynamic performance with the parameters varied. The proposed exact and approximate methods are useful.

81-2366

Load-Carrying Capacity of a Journal Bearing under Dynamic Loading

M. Sivák, Ľ. Šipoš, and B. Sivák

Univ. College of Forestry and Wood Tech., Zvolen, Czechoslovakia, Wear, 66 (3), pp 345-354 (Feb 16, 1981) 6 figs, 1 table, 11 refs

Key Words: Bearings, Journal bearings, Numerical methods

A method of obtaining the simultaneous solution of the Reynolds equation for dynamically loaded bearings by using a suitable numerical method is briefly outlined. It is assumed that the relation between the relative radial velocity and the hydrodynamically effective angular velocity of the journal is known. The solution is illustrated by graphs and a table. Examination of the application of separate solutions of the Reynolds equation in Holland's method for solving the motion of the journal center suggests that an error exists which is not always negligible. Therefore a modification of Holland's method based on the simultaneous solution derived in this paper is proposed.

GEARS

(Also see No. 2302)

81-2367

Effects of Addendum Modification on Bending Fatigue Strength of Spur Gears

S. Oda and K. Tsubokura

Faculty of Engrg., Tottori Univ., Minami 4-101, Koyama-cho, Tottori, Japan, Bull. JSME, 24 (190), pp 716-722 (Apr 1981) 15 figs, 2 tables, 11 refs

Key Words: Spur gears, Fatigue life, Structural modification effects

A study on the effects of addendum modification on bending fatigue strength of spur gears of cast iron and cast steel is presented. Analysis is made regarding the effects of addendum modification on the true stresses at the fillet in connection with the worst loading point and also on the bending fatigue strength of gear teeth. Bending fatigue strength of cast iron and cast steel gears can be improved by selecting the proper amount of addendum modification. Addendum modification factor B_x for bending strength is derived from the analytical and experimental results, and the bending fatigue strength of profile shifted gears can be estimated with fairly high accuracy by introducing this factor into the strength design of gears. Effects of addendum modification on both the contact ratio and the contact ratio factor are discussed.

81-2368

Factors Affecting Fatigue Strength of Nylon Gears

J.H. Chen, F.M. Juarbe, and M.A. Hanley

Polymer Corp., Reading, PA, J. Mech. Des., Trans. ASME, 103 (2), pp 543-548 (Apr 1981) 7 figs, 6 tables, 9 refs

Key Words: Gears, Fatigue life

The effects of some of the factors which influence fatigue strength of molybdenum disulphide (MoS_2) filled cast nylon (type 6) gears such as diametral pitch, pressure angle, pitch line velocity, stress level, and lubrication were investigated. It was found that nylon gears, when properly designed and installed, are subject to minimal wear. Premature failures do occur through tooth interference caused by thermal expansion, tooth deflection and creep of the material. The importance of a proper backlash is discussed. Design capacities of nylon gears using formula and tables are presented.

81-2369

Bending Fatigue Tests of High Speed Spur Gears

I. Yuruzume and H. Mizutani

Mech. Engrg. Lab., Ibaraki, Japan, J. Mech. Des., Trans. ASME, 103 (2), pp 466-473 (Apr 1981) 15 figs, 4 tables, 14 refs

Key Words: Gears, Fatigue tests, Structural modification effects

Effects of addendum modification of tooth profiles on the bending fatigue strength of high speed spur gear are discussed. Bending load capacity and running performance comparisons between the gear with standard tooth profile and the two shifted gears of which tooth addendum modification coefficients were 0.35 and 0.8. The maximum normal load of the gear with addendum modification coefficient 0.8 at 10^7 (10 million) cycles was 1.8 kNsmm per unit tooth width. The maximum Hertz stress of this gear was 2.43 x 10^9 Nsm^2.

81-2370

Factors Influencing Instability and Resonances in Geared Systems

M. Benton and A. Seireg

Engr. R&D Div., E.I. duPont, Wilmington, DE 19898, J. Mech. Des., Trans. ASME, 103 (2), pp 372-378 (Apr 1981) 13 figs, 41 refs

Key Words: Gears, Stability, Resonant response

The parameters influencing high dynamic magnifications and instabilities in multiple-reduction geared systems are investigated. These factors include the effect of external excitations, system inertia, variation in mesh stiffness, contact ratio and damping in the mesh. Design procedures and data are given to aid the designer in predicting system performance beforehand. The reported procedure and data can be used as a guide for safe design and application of geared systems with minimum calculations.

81-2371

Effects of Moving Speeds of Dynamic Loads on the Deflections of Gear Teeth

K. Nagaya and S. Uematsu

Dept. of Mech. Engrg., Faculty of Engrg., Gunma Univ., Kiryu, Gunma, Japan, J. Mech. Des., Trans. ASME, 103 (2), pp 357-363 (Apr 1981) 3 figs, 14 refs

Key Words: Gears, Gear teeth, Stability

For the dynamic response problems of gear teeth, the dynamic loads which act upon the gear teeth should be considered as a function of both the position and the moving speed. In previous studies, the effects of the moving speed have not been considered. In this paper the effects of the moving speed of dynamic loads on the deflection and the bending moment of the gear tooth are investigated. The results are obtained from the elastodynamic analysis of the tapered Timoshenko beam.

81-2372

An Extended Model for Determining Dynamic Loads in Spur Gearing

R. Kasuba and J.W. Evans

Dept. of Mech. Engrg., Cleveland State Univ., Cleveland, OH 44115, J. Mech. Des., Trans. ASME, 103 (2), pp 398-409 (Apr 1981) 14 figs, 2 tables, 37 refs

Key Words: Gears, Spur gears, Digital techniques, Mathematical models

In this study a large scale digitized approach is used for an uninterrupted static and dynamic analysis of spur gearing. An interactive method was developed to calculate directly the variable gear mesh stiffness as a function of transmitted load, gear profile errors, gear tooth deflections and gear hub torsional deformation, and position of contacting profile points. The developed methods are applicable to both the normal and high contact ratio gearing. Certain types of simulated sinusoidal profile errors and pitting can cause interruptions of the normal gear mesh stiffness function and, thus, increase the dynamic loads in gearing.

FASTENERS

81-2373

Fatigue Strength of Screw Joints of Large Nominal Diameter (Dauerfestigkeit von Schraubenverbindungen grosser Nenndurchmesser)

W. Koenigsmann and G. Vogt

Mannesmann Forschungsinstitut GmbH, Duisburg, Germany, Konstruktion, 33 (6), pp 219-231 (June 1981) 10 figs, 5 tables, 18 refs

(In German)

Key Words: Fatigue life, Joints (junctions), Steel

Experimental results with large heat-treated steel screw joints of a diameter of up to 320 mm show that the effect of size on the fatigue strength of the joint is not as great as it is often assumed. Other factors, such as nonuniform stress concentration, diverse manufacturing quality and variable material factors also have a considerable effect. Methods are proposed for the determination of these factors and their values enabling to attain a tensile strength of up to 300 N/mm^2, instead of the usual 60 to 100 N/mm^2.

81-2374

Fatigue Behavior of Spot Welded High Strength Steel Joints

R.B. Wilson and T.E. Fine

Inland Steel Res. Lab., SAE Paper No. 810354

Key Words: Fatigue tests, Testing techniques, Welded joints, Joints (junction), Steel

A new fatigue test specimen configuration has been developed which allows testing of spot welded joints in a fully reversed axial fatigue mode in a life range from 5×10^3 to 1×10^7 cycles. The specimen, a unique square concentric tube arrangement, tests four spot welds simultaneously. The materials tested in this program included three dual-phase steels, an SAE 940X grade, SAE 1020 steel and a cold rolled, low carbon steel - SAE 1006AK, for purposes of comparison. The general results indicate the superiority of the dual-phase steels in the low life region with all steels showing equivalent behavior beyond 5×10^5 cycles.

81-2375

Fatigue Life Estimation on HSLA Chassis Frame

H. Shirasawa, J. Jizaimaru, T. Mizoguchi, and N. Tada

Kobe Steel, Ltd., Japan, SAE Paper No. 810358

Key Words: Automobile bodies, Joints (junctions), Welded joints, Steel, Fatigue tests

Fatigue tests were performed on five kinds of fillet welded joints on 2.6 mm thick HSLA steel sheets, to evaluate the fatigue life of automotive HSLA chassis frame with different joint geometries under various loading conditions. Specimens were made by CO_2 gas arc welding with 1.2 mm diameter wire. During the fatigue tests at stress ratio (R) = −1, dynamic strain was measured using a 3 mm strain gage cemented on the sheet surface nearest to the toe. Data were discussed by nominal stress as well as by local strain.

81-2376

Stiffness and Damping Coefficients at Screw Joint Locations (Steifigkeits- und Dämpfungskennwerte verschraubter Fügestellen)

M. Weck and G. Petuelli

Laboratorium f. Werkzeugmaschinen und Betriebslehre (WZL) der RWTH Aachen, Germany, Konstruktion, 33 (6), pp 241-245 (June 1981) 11 figs, 6 refs

(In German)

Key Words: Joints (junctions), Stiffness coefficients, Damping coefficients, Machine tools

A combined experimental-analytical procedure is developed for the calculation of dynamic behavior of machine tools. The procedure is based on test stand data and enables to calculate the stiffness and damping coefficients of the joint, the weakest link of a machine tool, independently of any mathematical models. The effect of lubrication and surface pressure and quality on these dynamic characteristics is investigated.

81-2377

Determination of In-Plane Flexibilities of Dovetail Joints Using Finite Element Method

T.D. Sachdeva and C.V. Ramakrishnan

Dept. of Mech. Engrg., Delhi College of Engrg., Delhi-110006, India, Intl. J. Mach. Tool Des. Res., 21 (2), pp 153-161 (1981) 8 figs, 8 refs

Key Words: Joints (junctions), Machine tools, Flexibility coefficients, Finite element technique

The flexibility of a machine tool joint is studied. Only in-plane deformations are considered and the contact is assumed frictionless. A finite element-based numerical procedure is used for determining the flexibility effects. Since dovetail joints are encountered frequently this is investigated in detail. The knee-column joint and the overarm-column joints of a milling machine are analyzed and the flexibility effects are represented by a 3 x 3 matrix.

CAMS

81-2378
On the Periodic Response of Cam Mechanism with Flexible Follower and Camshaft
A. Midha and D.A. Turcic
Dept. of Mech. Engrg., Pennsylvania State Univ., University Park, PA 16802, J. Dyn. Syst. Meas. and Control, Trans. ASME, 102 (4), pp 255-264 (Dec 1980) 14 figs, 16 refs

Key Words: Cam followers, Periodic response

Researchers in recent years have shown a great deal of interest in the study of the dynamic response of cam-follower systems, with one or more of its compo ents treated as being elastic. Within the assumption of a linear analysis, and limited to stable regions, a single degree-of-freedom linear second order differential equation of motion is developed for a cam mechanism consisting of elastic follower and camshaft. The governing equation is shown to possess time-dependent periodic coefficients, for a constant input angular velocity. Conventionally, the rise portion of the cam motion cycle has been treated as the source of excitation, and the transient follower-motion computed during the excitation (rise) as well as the subsequent dwell periods. The one basic assumption in these works, however, has been that the residual vibration is damped out during the dwell period and does not carry over to the next motion cycle. A method is presented here for not only incorporating the excitation effects due to the return stroke, but also for obtaining the steady-state response of the follower.

STRUCTURAL COMPONENTS

STRINGS AND ROPES

81-2379
Periodic Motion of a String Vibrating in the Presence of a Point Obstacle (Mouvements périodiques d'une corde Vibrante en Présence d'un Obstacle Ponctuel)
H. Cabannes
Laboratoire de Méchanique Théorique (associé au C.N.R.S.), Université Pierre-et-Marie-Curie, 4, place Jussieu, 75005 Paris, France, J. de Mécanique, 20 (1), pp 41-58 (1981) 7 figs, 6 refs
(In French)

Key Words: Strings, Periodic response

A string fixed at both ends can oscillate in a plane in which there is a fixed point obstacle placed in the middle of the line joining the ends A and B of the string. The string is initially at rest with a prescribed shape, symmetric with respect to the normal mid-plane of the segment AB, and the displacement (transverse departure from equilibrium) has a minimum and two equal maxima. It is proven that, when the ratio of the displacements of these extrema is rational, the motion of the string is periodic and the period is computed.

CABLES
(Also see No. 2388)

81-2380
Comparison of Finite Element and Lumped Parameter Methods for Oceanic Cables
J.W. Leonard and J.H. Nath
Dept. of Civil Engrg., Oregon State Univ., Corvallis, OR 97331, Engrg. Struc., 3 (3), pp 153-157 (July 1981) 5 figs, 14 refs

Key Words: Cables (ropes), Submerged structures, Hydrodynamic excitation, Finite element technique, Lumped parameter method, Continuous parameter method

The basic foundations, similarities and fundamental differences between the finite element methods and the lumped parameter methods of analysis for oceanic cables under hydrodynamic load conditions is examined. The continuum method is presented as a ground truth prior to presenting each aspect of the approximate method derivations.

BARS AND RODS
(Also see Nos. 2454, 2455)

81-2381
On the Lateral Vibration of a Boring-Rod in the Deep Sea
K. Aso and K. Kan

Mining College, Akita Univ., Akita, Japan, Bull. JSME, 24 (190), pp 708-715 (Apr 1981) 14 figs, 9 refs

Key Words: Rods, Drills, Drill ships, Lateral vibration

The lateral vibration and bending stress of a boring-rod induced by drifting and rolling motions of a drilling vessel floating on the deep sea were analyzed theoretically. The results of this study predict when and where the maximum displacement and bending stress occur along the rod, depending on a given damping factor of the surrounding water. When the non-dimensional damping factor, N, defined in this paper, is less than about 1.0, resonant vibrations of the rod are caused by the vessel-motions, whereas they disappear when N exceeds the above value. In this case, however, the maximum bending stress increases with an increasing frequency of vibration of the rod.

BEAMS

81-2382
The Second Frequency Spectrum of Timoshenko Beams

G.R. Bhashyam and G. Prathap

Dept. of Aerospace and Mech. Engrg., Univ. of Arizona, Tucson, AZ 85721, J. Sound Vib., 76 (3), pp 407-420 (July 8, 1981) 3 figs, 4 tables, 18 refs

Key Words: Beams, Timoshenko theory, Spectrum analysis

A second spectrum of frequencies was reported in early analytical work on the vibrations of Timoshenko beams. From a recent finite element analysis with a high precision element it was concluded that there is no separate second spectrum of frequencies except for the special case of hinged-hinged beams and it was asserted that previous investigators had misinterpreted some frequencies thus introducing the notion of second frequencies. In this paper, a simple linear beam element with independent displacement fields and reduced integration to eliminate shear locking is used and enables one to detect the second spectrum accurately. Guidelines are provided which help to identify and classify the frequencies into two separate spectra.

81-2383
Inelastic Beams for Seismic Analysis of Structures

S.A. Anagnostopoulos

Inst. of Tech. Seismology and Earthquake Resistant Structures, Salonica, Greece, ASCE J. Struc. Div., 107 (7), pp 1297-1311 (July 1981) 11 figs, 12 refs

Key Words: Beams, Prismatic bodies, Seismic excitation, Seismic analysis

The post-yield flexural characteristics of prismatic members with bilinear moment-curvature properties are investigated. The objective is to improve point hinge modeling of such members for inelastic dynamic analyses of large structures subjected to seismic excitations. By comparing incremental secant stiffness ratios derived under different loading patterns, an antisymmetric end loading can be used to derive improved average post-yield properties that approximately account for the spread of yielding. Two sets of curves are presented for use in practical applications: the first gives equivalent post-yield stiffness ratios and the second the corresponding idealized yield moments. Ductility factors frequently used in practice are also examined, and some clarifications are made that are aimed at eliminating certain ambiguities associates with such factors.

81-2384
Free Vibration of Thin-Walled Open Section Beams with Unconstrained Damping Treatment

S. Narayanan, J.P. Verma, and A.K. Mallik

Machine Dynamics Lab., Dept. of Applied Mechanics, Indian Inst. of Tech., Madras, 600036, India, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 169-173 (Mar 1981) 5 figs, 1 table, 15 refs

Key Words: Beams, Stiffened structures, Layered damping, Flexural vibration, Torsional vibration, Coupled response

Free-vibration characteristics of a thin-walled, open cross-section beam, with unconstrained damping layers at the flanges, are investigated. Both uncoupled transverse vibration and the coupled bending-torsion oscillations, of a beam of a top-hat section, are considered. Numerical results are presented for natural frequencies and modal loss factors of simply supported and clamped-clamped beams.

81-2385
Responses of Continuous, Elastically Supported Beam Guideways to Transit Loads

J.F. Wilson and S.T. Barbas

School of Engrg., Duke Univ., Durham, NC 27706, J. Dyn. Syst. Meas. and Control, Trans. ASME, 102 (4), pp 247-254 (Dec 1980) 12 figs, 1 table, 11 refs

Key Words: Beams, Bernoulli-Euler method, Suspended structures, Rapid transit railways, Guideways, Moving loads

Solutions for nondimensional dynamic response histories are formulated for an undamped, continuous, Bernoulli-Euler beam resting on discrete, evenly-spaced, equal elastic supports. Responses depend on the distribution of the constant force loads, a dimensionless load speed parameter, and the ratio of support stiffness to beam stiffness. Peak midspan moments and deflections are calculated over a wide range of system parameters for several beam configurations. Results are that the extreme end spans have the peak dynamic responses. These responses increase as the relative support stiffness increases, and responses may become unbounded. Experimental measurements complement the calculations. Results are applicable to the design of cable-stayed guideways for advanced transit systems.

81-2386

Large Deflections and Large-Amplitude Free Vibrations of Straight and Curved Beams

J.N. Reddy and I.R. Singh

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, Intl. J. Numer. Methods Engrg., 17 (6), pp 829-852 (June 1981) 10 figs, 4 tables, 47 refs

Key Words: Beams, Curved beams, Large amplitudes, Flexural vibration, Natural frequencies, Finite element technique, Rotatory inertia effects, Transverse shear deformation effects

This paper is concerned with the large-deflection (bending and free vibration) analysis of thin elastic curved beams by conventional and mixed finite element methods. The conventional finite element method is based on the total potential energy expression, whereas the mixed method is based on a Reissner-type variational statement and involves the bending moments and deflections as primary dependent variables. Incremental and direct formulations are presented for both methods. The nonlinearity is included in the numerical method via an iterative procedure (i.e., the in-plane force due to the large deflection is not treated as constant but included under the integral in the energy expression). In the case of vibrations, the transverse shear and rotary inertia effects are also included. A number of numerical examples of beams with various edge conditions are analyzed for deflections and natural frequencies, and the results are compared with those reported in the literature.

81-2387

Comparative Behavior of a Nonlinear System Subjected to Impulsive Load

J.C. Anderson and S.F. Masri

Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA 90007, Nucl. Engrg. Des., 64 (3), pp 423-431 (Apr 1981) 9 figs, 1 table, 3 refs

Key Words: Nonlinear systems, Beams, Cantilever beams, Impact response, Base excitation

Analytical and experimental studies of the dynamic response of a system with geometric and material nonlinearity are described. The dynamic excitation consists of an impulsive base acceleration. The dynamic system consists of a cantilever beam with a lumped mass and a gapped support beam at the free end. The material nonlinearity considers both the effect of yielding and the effect of strain rate on the initial yield level. Two analytical models are considered. The first is a generalized single degree-of-freedom system with a bilinear hysteresis. The second is a multiple degree-of-freedom system which uses beam elements with concentrated plastic hinges to represent the system. Numerical methods are used to solve the resulting equations of dynamic equilibrium. Experimental studies are performed and accelerations and residual plastic deformations are measured. Critical comparisons are made between the calculated and measured responses. The results show that the single degree of freedom model may overestimate the displacement response.

CYLINDERS

(Also see Nos. 2413, 2415)

81-2388

Vortex-Induced Vibrations of Structures

S.A. Hall

Ph.D. Thesis, California Inst. of Tech., 224 pp (1981) UM 8111494

Key Words: Vortex-induced vibration, Cylinders, Cables (ropes)

Vortex-induced oscillations, often of concern when a bluff structure is exposed to fluid cross-flow, are considered herein using a semi-empirical modeling approach. Based on the fluid momentum theorem, the model involves a highly simplified abstraction of the complex flow field, and major assumptions concerning the nature of the coupling between the fluid and the oscillating structure. Three prototype problems are studied: harmonically forced cylinders, spring-mounted cylinders, and taut elastic cables; in each case the structure is assumed to be of circular cross-section and situated in a uniform cross-flow. Only oscillations transverse to the flow are considered. The problem of modal interaction for elastic cables, typically of interest when the fluid flow excites high-mode-number resonances, is given particular attention.

81-2389

Fluctuating Pressures on an Oscillating Square Prism

R.H. Wilkinson

Inst. of Oceanographic Sciences, Crossway, Taunton, Somerset, UK, Aeronaut. Quart., 32 (2), pp 97-110 (May 1981) 6 figs, 9 refs

Key Words: Prismatic bodies, Cylinders, Vortex-induced vibration, Vortex shedding

The fluctuating loading on a cylindrical bluff body due to vortex shedding increases if the body is capable of vibration. This is a result of amplification of the fluctuating pressures around a two-dimensional section of the body together with an improvement of the spanwise correlation of the vortex shedding. Measurement of the fluctuating forces on the cylinder during this process gives no guide as to the relative magnitude of these effects. Root mean square fluctuating pressure distributions and pressure correlations across a chord are presented for a square cylinder with front face normal to the approach flow while stationary and during forced vibration. The fluctuating lift coefficient for a two-dimensional section of the cylinder and its maximum amplification during vibration are calculated.

81-2390

Interaction of Acoustic Shock Waves with a Cylindrical Elastic Shell Immersed Near a Hard Surface

H. Huang

Naval Res. Lab., Washington, DC 20375, Wave Motion, 3 (3), pp 269-278 (July 1981) 5 figs, 8 refs

Key Words: Acoustic waves, Shock waves, Shells, Cylindrical shells, Interaction: structure-fluid

The plane strain transient response of a cylindrical elastic shell immersed near a hard surface (with Neumann pressure boundary condition) impinged upon by plane acoustic shock waves is studied by the image method. The equations of motion of the shell, its surrounding fluid and their images are solved by the separation of variable and Laplace transform procedures. Due to the fact that there is a time lag for the reflected waves from the hard surface to arrive at the shell, the inverse Laplace transform and therefore the shell response can be accurately calculated stage by stage using an integral equation technique. Numerical results for the time histories of the stress and velocity at various locations of the shell are presented.

COLUMNS

81-2391

Resonance Instabilities of Cantilevered Columns Subjected to Transient Axial Loads

S.T. Noah and V. Sundararajan

Mechanical Engrg. Dept., Texas A&M Univ., College Station, TX 77843, Intl. J. Mech. Sci., 23 (6), pp 345-357 (1981) 8 figs, 11 refs

Key Words: Columns (supports), Cantilever beams, Transient excitation, Damped structures, Parametric resonance

The response of damped cantilevered columns to transient axial loads of the follower and unidirectional type is investigated. Coupling between lateral and axial motions is accounted for by including the effect of rotation on the axial strain of the column. For certain values of load and column parameters, parametric resonance of lateral modes can occur due to transient axial motion after the load is removed. The parametric resonance can be of the simple or the combination type, depending on the particular geometrical configuration of the column. Numerical results are obtained in order to study the influence of the load-column parameters on the magnitude of the maximum lateral response reached and the time at which the maximum occurs. The significant parameters of the system are identified as those of the amplitude and duration of the end load, the slenderness ratio for the column, and the amount of internal damping present.

FRAMES AND ARCHES

81-2392

Seismic Response of Reinforced Concrete Frames

J. Humar

Dept. of Civil Engrg., Rm. 277, C.J. Mackenzie Bldg., Carleton Univ., Ottawa, Canada K1S 5B6, ASCE J. Struc. Div., 107 (7), pp 1215-1232 (July 1981) 18 figs, 19 refs

Key Words: Frames, Concretes, Reinforced concrete, Earthquake response, Multistory buildings, Seismic response

Analytical studies of the elastic and inelastic response of reinforced concrete frames subjected to earthquake motion are presented. The effect of stiffness degradation on the seismic response and in particular on ductility demand is examined. Several single-story frames are analyzed. Studies of multistory frames are also presented.

MEMBRANES, FILMS, AND WEBS

81-2393

Free Vibration of a Membrane Stretched by Inextensible Strings at Opposite Edges

T. Irie and K. Yoda

Dept. of Mech. Engrg., Hokkaido Univ., Sapporo 060, Japan, J. Sound Vib., 76 (3), pp 381-389 (July 8, 1981) 5 figs, 1 table, 17 refs

Key Words: Membranes (structural members), Natural frequencies, Mode shapes

An analysis is presented for the free vibration of a membrane stretched by inextensible strings along two opposite edges. The membrane is transformed into a square membrane of unit length by a certain transformation of variables. The transverse deflection of the membrane is expressed in a series of the products of the deflection functions of strings (strips of membrane) parallel to the edges of the square membrane, and the frequency equation is derived by the Ritz method. The natural frequencies and the mode shapes are calculated numerically up to higher modes for membranes symmetrical with respect to the center lines by the application of the present method.

PANELS

81-2394

Torque-Balanced Vibrationless Rotary Coupling

D.M. Miller

Dept. of Energy, Washington, DC, US Patent No. 4,203,303, 6 pp (May 1980)

Key Words: Couplings, Design techniques

A torque-balanced vibrationless rotary coupling for transmitting rotary motion without unwanted vibration into the spindle of a machine tool is described. A drive member drives a driven member using flexible connecting loops which are connected tangentially and at diametrically opposite connecting points through a free floating ring.

PLATES

(Also see Nos. 2294, 2448, 2453, 2489)

81-2395

Significance of In-Plane Inertia Forces in the Vibration Analysis of Three-Layered Circular Plates

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Inst. of Materials and Machine Mech., Slovak Academy of Sciences, ul. Februárového vit. 75, 81005 Bratislava, Czechoslovakia, J. Sound Vib., 76 (3), pp 421-441 (July 8, 1981) 9 figs, 3 tables, 10 refs

Key Words: Plates, Sandwich structures, Circular plates, Inertial forces, Vibration analysis

The equations of vibratory motion for circular sandwich plates are derived. The plate under consideration is assumed to possess a soft core with special polar orthotropy. Free axisymmetric vibration modes of a circular plate clamped all around the outside radius are numerically analyzed. Computer investigations are carried out for a wide range of introduced parameters. The influence of the in-plane inertia forces upon dynamical characteristics of the plate is discussed. The results of computer studies are discussed and graphically presented.

81-2396

Dynamic Stability of Orthotropic Annular Plates under Pulsating Torsion

J. Tani

Inst. of High Speed Mechanics, Tohoku Univ., Sendai, Japan, J. Acoust. Soc. Amer., 69 (6), pp 1688-1694 (June 1981) 8 figs, 1 table, 32 refs

Key Words: Annular plates, Plates, Orthotropism, Torsional excitation, Pulse excitation

The dynamic stability of clamped, polar orthotropic annular plates under pulsating torsion is theoretically analyzed with the effect of the static torsion taken into consideration. The Galerkin method is used to reduce the problem to that for a finite degree-of-freedom system, the stability boundaries of which are determined by utilizing Hsu's result for coupled Hill's equations. The instability regions of both principal and combination resonances are determined for a wide range of exciting frequencies. The variation in the polar orthotropic material property is found to change significantly the wavenumber dependence of the dynamic stability.

81-2397

Response of an Elastic Plate on a Pasternak Foundation to a Moving Load

K. Watanabe

Dept. of Mech. Engrg. II, Tohoku Univ., Sendai 980, Japan, Bull. JSME, 24 (191), pp 775-780 (May 1981) 8 figs, 1 table, 8 refs

Key Words: Plates, Elastic properties, Pasternak foundations, Moving loads

The response of an elastic plate to a moving load is considered. The plate is resting on a Pasternak foundation and

the load moves uniformly with a constant velocity. The deflection of the plate is expressed in the form of integration. Combinations of the velocity and the foundation parameters yield the expression in five types of integration. It is shown that the critical velocity of the load becomes larger than that of the Winkler foundation due to the presence of a shear layer in the Pasternak foundation. Numerical computations are carried out for some combinations of the parameters.

81-2398
Elastic Instability of a Uniformly Compressed Annular Plate with Axisymmetric Initial Deflection

J. Tani and N. Yamaki
Inst. of High Speed Mechanics, Tohoku Univ., Sendai, Japan, Intl. J. Nonlin. Mechanics, 16 (2), pp 213-220 (1981) 7 figs, 6 refs

Key Words: Plates, Annular plates, Initial deformation effects

A theoretical study of the elastic instability of a uniformly compressed, thin, circular annular plate with axisymmetric initial deflection is presented. The dynamic version of the nonlinear Marguerre plate theory is used, and the linear free vibration problems around the axisymmetric finite deformation of the plate are solved by a finite difference method. By examining the frequency spectrum with various asymmetric modes, the critical compressive load under which the axisymmetric additional deformation of the plate becomes unstable due to the bifurcation buckling is determined, which is found to depend severely on the magnitude of the axisymmetric initial deflection.

81-2399
Forced Bending Vibrations of an Allside Clamped Orthotropic Plate Loaded by a Concentrated Force by Taking into Account Amplitude Dependent Nonlinear Material Damping

S. Katsaitis
National Technical Univ. Athens, Athens, Greece, Forsch. Ingenieurwesen, 47 (2), pp 54-61 (1981) 3 figs, 3 tables, 4 refs

Key Words: Plates, Orthotropism, Material damping, Forced vibration, Flexural vibration

The behavior of a frequency dependent linear and a frequency independent nonlinear material damping, whose nonlinearity depends on the maximum vibration distortion, is discussed for the case of forced bending vibrations of a plate. The plate is rectangular, orthotropic, and loaded by a concentrated force. For an approximate solution of the nonlinear partial differential equation a proper mathematical method is introduced.

81-2400
Vibration of an Elastic Circular Plate on an Elastic Half Space - A Direct Approach

S. Krenk and H. Schmidt
Ris National Lab., 4000 Roskilde, Denmark, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 161-168 (Mar 1981) 6 figs, 22 refs

Key Words: Plates, Circular plates, Elastic half-space, Axisymmetric vibrations

The axisymmetric problem of a vibrating elastic plate on an elastic half space is solved by a direct method, in which the contact stresses and the normal displacements of the plate are taken as the unknown functions. The influence functions that give the displacements in terms of the stresses are determined for the half space and the plate. Displacement continuity then takes the form of an integral equation. Due to the half space the kernel is weakly singular, and a special solution technique that accounts for this is employed. The solution implies a direct matrix relation between the expansion coefficients of the contact stresses and plate deformations.

81-2401
Exact Equations for the Large Inextensional Motion of Elastic Plates

J.G. Simmonds
Dept. of Applied Math. and Computer Science, Univ. of Virginia, Charlottesville, VA 22901, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 109-112 (Mar 1981) 3 refs

Key Words: Plates, Dynamic structural analysis

The governing equations for plates that twist as they deform are reduced to 14 differential equations, first-order in a single space variable and second-order in time. Many of the equations are the same as for statics. Nevertheless, the extension to dynamics is nontrivial because the natural coordinates to use to describe the deformed, developable midsurface are not Lagrangian. The plate is assumed to have two curved, stress-free edges, one built-in straight edge, and

one free straight edge acted upon by a force and a couple. There are 7 boundary conditions at the built-in end and 7 at the free end.

81-2402

Propagation of Elastic Pulses and Acoustic Emission in a Plate. Part 1: Theory

A.N. Ceranoglu and Y.-H. Pao
Bogazici Univ., Istanbul, Turkey, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 125-132 (Mar 1981) 3 figs, 2 tables, 30 refs

Key Words: Plates, Acoustic emission, Failure detection, Pulse excitation

Transient waves generated by a variety of dynamic nuclei of strains including a concentrated force, a single-couple, a double-force, a double-couple without moment, a center of rotation, and a center of explosion in an elastic plate are analyzed. Some of these sources, or a combination of them, could be used to model the dynamic process of material defects. The analysis is based on the generalized ray theory and Cagniard's method and the solutions are presented in terms of Green's dyadics for a plate.

81-2403

Propagation of Elastic Pulses and Acoustic Emission in a Plate. Part 2: Epicentral Responses

A.N. Ceranoglu and Y.-H. Pao
Bogazici Univ., Istanbul, Turkey, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 133-138 (Mar 1981) 6 figs, 2 tables, 6 refs

Key Words: Plates, Acoustic emission, Failure detection, Pulse excitation

Cagniard's method is applied to obtain the transient response along the epicentral points of an elastic plate. Numerical results are shown for a concentrated force, a single-couple, a double force, a double-couple without moment and a center of rotation up to 10 transit time required for the longitudinal (P)-wave to cross the thickness of the plate.

81-2404

Propagation of Elastic Pulses and Acoustic Emission in a Plate. Part 3: General Responses

A.N. Ceranoglu and Y.-H. Pao
Bogazici Univ., Istanbul, Turkey, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 139-147 (Mar 1981) 18 figs, 45 refs

Key Words: Plates, Acoustic emission, Failure detection, Pulse excitation

A modified version of Cagniard's method is applied to obtain the transient response of the plate at any location due to point sources applied at the surface or the interior of the plate. Numerical results are shown for a concentrated force, a single-couple, a double-force, a double-couple without moment and a center of rotation, at locations up to six plate thicknesses from the source.

81-2405

Some Considerations on Thermal Shock Problems in a Plate

Y. Takeuti and T. Furukawa
Dept. of Mech. Engrg., Univ. of Osaka Prefecture, Mozu, Sakai, 591, Japan, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 113-118 (Mar 1981) 10 figs, 1 table, 8 refs

Key Words: Plates, Thermal excitation

A rigorous treatment to find the exact solution for thermal shock problems in a plate when the following two effects are taken into account is examined: dynamic treatment due to the presence of an inertia term; a coupled thermal stress problem in the presence of a thermoelastic coupling term. The significance of these effects on the thermal stress distribution when a sudden change of temperature occurs can be determined.

SHELLS

81-2406

Some Approximations in the Linear Dynamic Equations of Thin Cylinders

M. El-Raheb and C.D. Babcock, Jr.
Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, J. Sound Vib., 76 (4), pp 543-559 (June 22, 1981) 3 figs, 3 tables, 22 refs

Key Words: Shells, Cylindrical shells, Linear theories, Error analysis

Theoretical analysis is performed on the linear dynamic equations of thin cylindrical shells to find the error committed by making the Donnell assumption and the neglect of in-plane inertia. The effect of these approximations is studied on a shell with classical simply supported boundary condition. The same approximations are then investigated for other boundary conditions from a consistent approximate solution of the eigenvalue problem. The Donnell assumption is valid at frequencies high compared with the ring frequencies, for finite length thin shells. The error in the eigenfrequencies from omitting tangential inertia is appreciable for modes with large circumferential and axial wave lengths, independent of shell thickness and boundary conditions.

81-2407

Vibrations of Laminated Filament-Wound Cylindrical Shells

J.B. Greenburg and Y. Stavsky
Technion-Israel Inst. of Tech., Haifa, Israel, AIAA J., 19 (8), pp 1055-1062 (Aug 1981) 8 figs, 6 tables, 16 refs

Key Words: Shells, Cylindrical shells, Layered materials, Fiber composites

The equations of motion, derived from a Love-type theory, are presented for laminated filament-wound cylindrical shells in which each layer is permitted an arbitrary fixed fiber orientation. A general method of solution is established, based upon the use of a complex finite Fourier transform. The frequency spectra of free natural vibrations are investigated for numerous single, bi- and tri-layered clamped or simply supported generally orthotropic shells. The effect of fiber orientation on the frequency response is found to be quite considerable in certain composite shells; for some shells the frequency is increased by a factor of 3.1 by simply choosing an optimal combination of fiber winding angles. Similar important effects are noted due to the combined action of shell heterogeneity and fiber winding angle.

81-2408

Viscoplastic Axisymmetrical Buckling of Spherical Shell Impulse Subjected to Radial Pressure

W. Wojewódzki and P. Lewiński
Instytut Mechaniki Konstrukcji Inzynierskich, Politechnika Warszawska, Warsaw, Poland, Engrg. Struc., 3 (3), pp 168-174 (July 1981) 9 figs, 16 refs

Key Words: Shells, Spherical shells, Impact response, Dynamic buckling

The solution of viscoplastic axisymmetrical buckling of a complete thin spherical shell subjected to radial pressure impulse is presented. Analytically, the problem is formulated as a superposition of small perturbations on the basic unperturbed motion. The influence of the meridional displacement on the magnitude of radial displacement, buckling mode and critical impulse is investigated. The influence of the viscosity and the initial imperfections of the geometry and loading is shown. Numerical results for a steel shell are presented diagrammatically.

81-2409

Transient Response of Fluid-Coupled Coaxial Shells

U.W. Stussi and P. Jemelka
Glauser, Studer, Stuessi, Witikonerstrasse, Zurich, Switzerland, J. Engrg. Indus., Trans. ASME, 107 (EM4), pp 679-692 (Aug 1981) 6 figs, 2 tables, 3 refs

Key Words: Shells, Cylindrical shells, Interaction: structure-fluid, Base excitation, Transient response, Frequency domain method, Substructuring methods

An analytical solution for the fluid-structure-foundation interaction of two fluid filled coaxial cylinders on a rigid base slab is presented. The system may be excited horizontally in an arbitrary manner at foundation level. The rocking of the base slab is taken into account. The fluid is chosen to be incompressible and inviscid. The analysis is performed in the frequency domain using substructuring technique. A corresponding computer code is developed. The numerical results illustrate the strong influence of fluid level and structural properties on the response.

81-2410

Nonlinear Response of an Elastic Cylindrical Shell to a Transient Acoustic Wave

T.L. Geers and C.-L. Yen
Lockheed Palo Alto Res. Lab., Appl. Mechanics Lab., 3251 Hanover St., Palo Alto, CA 94304, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 15-24 (Mar 1981) 14 figs, 22 refs

Key Words: Shells, Cylindrical shells, Acoustic excitation, Sound waves, Interaction: structure-fluid

Governing equations are developed for the nonlinear response of an infinite, elastic, circular cylindrical shell submerged in an infinite fluid medium and excited by a transverse, transient acoustic wave. These equations derive from circum-

ferential Fourier-series decomposition of the field quantities appearing in appropriate energy functionals, and from application of the "residual potential formulation" for rigorous treatment of the fluid-structure interaction. Extensive numerical results are presented.

RINGS

81-2411

On the Non-Linear Vibration of a Thin Ring with Steady Pressurization

C.C. Glynn and T.L. Maxwell

General Electric Co., Aircraft Engine Group, Evendale, OH, Intl. J. Nonlin. Mechanics, 16 (2), pp 105-116 (1981) 6 figs, 9 refs

Key Words: Rings, Flexural vibration, Large amplitudes, Nonlinear theories

Large amplitude, flexural oscillations of an inextensible, linearly elastic, pressurized ring are analyzed. Non-linear governing equations describing the planar motion of a thin rod curved in its undeformed state and subject to a distributed load applied normal to the neutral axis are developed using Hamilton's extended principle. The equations are specialized to study the behavior of a circular ring, and approximate solutions are obtained for a single mode response by a perturbation technique. Free, undamped oscillations and forced response of the ring near resonance are discussed. The influence of the magnitude of pressurization on the non-linear character of the motion is investigated.

PIPES AND TUBES

81-2412

Vibration in Nuclear Heat Exchangers Due to Liquid and Two-Phase Flow

W.J. Heilker and R.Q. Vincent

Combustion Engrg., Inc., Chattanooga, TN 37402, J. Engrg. Power, Trans. ASME, 103 (2), pp 358-366 (Apr 1981) 10 figs, 1 table, 9 refs

Key Words: Tubes, Heat exchangers, Nuclear power plants, Vibration tests

In order to optimize a steam generator tube bundle support system, it is necessary to understand the differences in vibration behavior of tube arrays subjected to a two-phase flow regime as compared to a single phase flow regime. The relationships discussed in this paper are based on findings derived from a comprehensive vibration testing program which included both water and simulated two-phase (air-water) flow regimes. Tube bundles of various configurations and spacings were tested in crossflow using 3/4 in. (1.9 cm) and 7/8 in. (2.2 cm) o.d. tubes with 36 in. (91 cm) span lengths and as many as 40 tubes per array. Sufficient test loop capacity was provided to drive most test array configurations up to and beyond fluid-elastic instability. Parameters obtained included displacement, effective force coefficients, damping coefficients, Strouhal numbers, and instability constants for various tube array configurations in both liquid and simulated two-phase flow mediums.

81-2413

Dynamics of Arrays of Cylinders with Internal and External Axial Flow

M.P. Païdoussis and P. Besancon

Dept. of Mech. Engrg., McGill Univ., Montreal, Quebec, Canada, J. Sound Vib., 76 (3), pp 361-379 (July 8, 1981) 6 figs, 18 refs

Key Words: Tube arrays, Cylinders, Heat exchangers, Fluid-induced excitation

Various aspects of the dynamics and stability of clusters of tubular cylinders containing internally flowing fluid and surrounded by a bounded external axial flow are examined. The general character of free motions is established by obtaining the eigenfrequencies of the system and studying their evolution with increasing flow, internal or external. Stability diagrams have been obtained for the critical flow velocities, beyond which the system would lose stability by buckling (divergence), under the combined effect of internal and external flow. Free vibration, following an initial disturbance of one of the cylinders, is studied, in order further to examine the effect of hydrodynamic coupling.

81-2414

Transient Response of a Gas-Controlled Heat Pipe

K.N. Shukla

Vikram Sarabhai Space Centre, Trivandrum, India, AIAA J., 19 (8), pp 1063-1070 (Aug 1981) 12 figs, 2 tables, 9 refs

Key Words: Pipes (tubes), Heat exchangers, Transient response

A combined analytical and experimental investigation of the transient response of a gas-controlled heat pipe with an absorption gas reservoir is presented. A mathematical model which considers the heat conduction in the condenser wall, the overall vapor core temperature, the diffusion of the vapor-gas interface, and the absorption of the control gas in the working fluid/wick structure matrix of the reservoir is developed for analysis. Experimental evaluation of the heat-pipe performance is made with methanol as a working fluid and ammonia and nitrogen as control gases. The combination of ammonia and methanol is considered for the soluble gas absorption reservoir, while nitrogen and methanol is considered for the standard gas reservoir. The performance of the two is compared.

81-2415

Fluidelastic Vibration of Cylinder Arrays in Axial and Cross Flow: State of the Art

M.P. Païdoussis
Dept. of Mech. Engrg., McGill Univ., Montreal, Quebec, Canada, J. Sound Vib., 76 (3), pp 329-360 (June 8, 1981) 19 figs, 118 refs

Key Words: Tube arrays, Cylinders, Fluid-induced excitation

A critical assessment is presented of the state of the art for flow induced vibrations of cylinder arrays in cross and axial flow. A short historical review is presented for cross flows in which the milestone contributions which have advanced our understanding of the flow induced vibration phenomena involved and/or our predictive ability are highlighted.

81-2416

On the Hydrodynamic and Acoustic Wall Pressure Fluctuations in Turbulent Pipe Flow Due to a 90° Mitred Bend

M.K. Bull and M.P. Norton
Dept. of Mech. Engrg., Univ. of Adelaide, Adelaide, South Australia 5000, Australia, J. Sound Vib., 76 (4), pp 561-586 (June 22, 1981) 24 figs, 12 refs

Key Words: Pipes (tubes), Fluid-induced excitation, Turbulence

When the fully-developed turbulent flow in a pipe of circular cross-section is forced to negotiate a 90° mitred bend, flow separation occurs at the inner and outer corners of the bend, with random switching of the separation regions from one side of the plane of symmetry of the bend to the other. The resulting disturbance to the fluctuating pressure field consists of intense non-propagating fluctuations over the region of the inner-wall separation, which near re-attachment have a maximum rms value of about 33% of the undisturbed center-line dynamic pressure, but are rapidly attenuated with downstream distance from the bend. Beyond about 12 diameters downstream the only remaining disturbance is an acoustic field comprising propagating higher order modes and plane waves, the latter making the larger contribution to the overall mean square pressure. Extensive spectral measurements of the wall pressure field for flow Mach numbers in the range 0·2 - 0·5 are presented, and regions where higher order modes are detectable are identified.

81-2417

Dynamic Response of Tapered Fluid Lines (1st Report, Transfer Matrix and Frequency Response)

T. Muto, Y. Kinoshita, and R. Yoneda
Faculty of Engrg., Gifu Univ., Japan, Bull. JSME, 24 (191), pp 809-815 (May 1981) 12 figs, 2 tables, 3 refs

Key Words: Pipelines, Variable cross section, Fluid-induced excitation, Transfer matrix method, Frequency response

A transfer matrix equation relating the pressure and volume flux in tapered fluid lines is derived under the assumption that the rate of divergence (or convergence) of the line is comparatively small. The model employed in the analysis is one of an unsteady viscous flow – the frequency-dependent effect of viscosity is taken into consideration. Natural frequencies and frequency response curves of the line systems are calculated from the matrix, and dynamic characteristics of systems are discussed under various pipe-end conditions. The experimental data obtained from frequency response tests are compared with theoretical analysis and validated.

81-2418

Behaviour of a Shallow Buried Pipeline under Static and Rolling Wheel Loads

R.G. Pocock, G.J.L. Lawrence, and M.E. Taylor
Transport and Road Res. Lab., Crowthorne, UK, Rept. No. TRRL-LR-954, 28 pp (1980)
PB81-165029

Key Words: Pipelines, Underground structures, Moving loads

The bending strains developed in an experimental shallow buried pipeline due to static and rolling wheel loads have been investigated. The instrumented pipeline, comprising

eight 3.7 m lengths of 100 mm internal diameter spun iron pipe with lead-run joints, was constructed under a weak pavement. Both good and poor bedding conditions were established Commercial vehicles having axle loads up to 10 Mg were used to traffic the buried pipeline at speeds of up to 48 km/h.

81-2419

Analytical Modeling of Buried Pipeline Response to Permanent Earthquake Displacements

T.D. O'Rourke and C.H. Trautmann

School of Civil and Environmental Engrg., Cornell Univ., Ithaca, NY, Rept. No. NSF/RA-800339, 98 pp (July 1980)

PB81-146896

Key Words: Pipelines, Underground structures, Seismic response, Mathematical models, Finite element technique

The performance of continuous and jointed buried pipelines subjected to permanent differential ground movements caused by earthquakes, is examined. Observations of damage along the Sylmar segment of the San Fernando fault zone show that pipelines with rubber gasket joints perform substantially better than those with cement-caulked joints, and that lines of Mannesman steel are more heavily damaged than lines composed of cast iron or other types of steel. Behavior of various types of pipeline coupling was studied and an assessment made of their vulnerability to differential ground movement. Results of finite element modeling of jointed pipeline response to strike-slip faulting are summarized.

DUCTS

81-2420

A Modal Separation Measurement Technique for Broadband Noise Propagating Inside Circular Ducts

E.J. Kerschen and J.P. Johnston

Stanford Univ., Stanford, CA 94305, J. Sound Vib., 76 (4), pp 499-515 (June 22, 1981) 6 figs, 18 refs

Key Words: Ducts, Sound propagation, Measurement techniques

A measurement technique which separates broadband noise propagating inside circular ducts into the acoustic duct modes is developed. The technique is also applicable to discrete frequency noise. The acoustic modes are produced by weighted combinations of the instantaneous outputs of microphones spaced around the duct circumference. The technique is compared with the cross spectral density approach presently available and found to have certain advantages and disadvantages. Considerable simplification of both the new technique and the cross spectral density approach occurs when no correlation exists between different circumferential mode orders. The properties leading to uncorrelated modes and experimental tests which verify this condition are discussed. The modal measurement technique is applied to the case of broadband noise generated by flow through a coaxial obstruction (nozzle or orifice) in a pipe. Different circumferential mode orders are shown to be uncorrelated for this type of noise source.

81-2421

Two-Dimensional Acoustic Wave Propagation in Elastic Ducts

Y.L. Sinai

Dept. of Appl. Math. Studies, Leeds Univ., Leeds LS2 9JT, UK, J. Sound Vib., 76 (4), pp 517-528 (June 22, 1981) 13 refs

Key Words: Ducts, Sound propagation, Elastic waves, Wave propagation

Integral transforms are employed in order to obtain a formal solution to the two-dimensional elastic-walled duct problem. The fluid inside the duct is stationary, inviscid and compressible, and is identical to the fluid outside the duct. A time-harmonic line source lies between the duct walls. With attention confined to the field inside the duct, an asymptotic analysis is implemented for high and low frequencies, yielding residues which are valid throughout the duct and branch-cut contributions which apply only in the far field.

81-2422

New Approach to the Solution of Eigenvalue Problems in Circular Flow Ducts (a Taylor Series Method)

S.-H. Ko

Naval Underwater Systems Ctr., New London, CT, J. Acoust. Soc. Amer., 70 (1), pp 205-212 (July 1981) 11 figs, 2 tables, 7 refs

Key Words: Ducts, Acoustic linings, Sound attenuation, Taylor series

Sound attenuation was investigated in acoustically lined circular ducts with fluid flow by using a Taylor series method for the solution of the eigenvalue problem. The governing

differential equation was numerically integrated across the duct cross section from the origin to the duct wall. The singularity of the differential equation at the origin was treated by analytically solving the differential equation valid only at the origin. By using values of the radial function and its derivatives at the origin, successive approximation of the eigenvalue were performed un*' he boundary condition at the duct wall was satisfied. ... values obtained by this method are presented. The sound attenuation was obtained by using the calculated eigenvalues.

81-2423

Acoustic Transmission Matrix of a Variable Area Duct or Nozzle Carrying a Compressible Subsonic Flow

J.H. Miles

NASA Lewis Res. Ctr., Cleveland, OH 44135, J. Acoust. Soc. Amer., 69 (6), pp 1577-1586 (June 1981) 2 figs, 30 refs

Key Words: Ducts, Variable cross section, Sound propagation

The differential equations governing the propagation of sound in a variable area duct or nozzle carrying a one-dimensional subsonic compressible fluid flow are derived and put in state variable form using acoustic pressure and particle velocity as the state variables. The duct or nozzle is divided into a number of regions. The region size is selected so that in each region the Mach number can be assumed constant and the area variation can be approximated by an exponential area variation. Consequently, the state variable equation in each region has constant coefficients. The transmission matrix for each region is obtained by solving the constant coefficient acoustic state variable differential equation. The transmission matrix for the duct or nozzle is the product of the individual transmission matrices of each region. Solutions are presented for several geometries with and without mean flow.

BUILDING COMPONENTS

81-2424

Dynamic Analysis of Steel Struts Subjected to Impulsive Loading with Linear Attenuation

G.-h. Li, Y.-g. Wang, and Z.-w. Zhou

Tong-ji Univ., Acta Mech. Solida Sinica, Chinese Soc. Theor. and Appl. Mechanics, No. 1, pp 1-11 (Nov 1981) 12 figs, 2 tables, 12 refs (In Chinese)

Key Words: Struts, Steel, Flexural vibration, Pulse excitation

Theoretical analyses and experimental researches on steel struts subjected to impulsive loading have been carried out. Steel struts subjected to longitudinal impulsive loading and transverse loading simultaneously are examined. The elastic vibration of struts is discussed, followed by a brief analysis of the elastic-plastic vibration. In this analysis, the following assumptions are adopted: owing to the long time duration of impulsive loading, the effects of stress wave propagation and reflection are neglected; as this paper mainly discusses the transverse vibration of struts with initial eccentricity, the longitudinal vibration is not considered here; when the elastic limit is exceeded, the strut is treated as a rigid-plastic system with a plastic hinge.

81-2425

Wind Direction Effects on Cladding and Structural Loads

E. Simiu and J.J. Filliben

Ctr. for Bldg. Tech., Natl. Bureau of Standards, Washington, DC, Engrg. Struc., 3 (3), pp 181-186 (July 1981) 4 figs, 3 tables, 6 refs

Key Words: Wind-induced excitation, Structural members, Design techniques

A simple procedure is proposed for estimating wind loads corresponding to various return periods, which takes into account directional information on both wind speeds and aerodynamic response. Examples of the application of the procedure are given, which show that cladding loads calculated without taking directional information on extreme wind speeds into account may in certain cases be larger than the actual loads by a factor of two or more. It is also shown that it is not appropriate, in general, to account for wind direction effects by multiplying loads determined without regard for these effects by a reduction factor of 0.8, as has been suggested in the literature. In its present form, the procedure is applicable to cladding panels and to members of relatively rigid structures in regions not subjected to hurricane winds.

81-2426

The Measurement of Sound Transmission at Structural Junctions by an Impulse Method

B.M. Gibbs and J.C. Davies

Dept. of Bldg. Engrg., Univ. of Liverpool, Liverpool L69 3BX, UK, J. Sound Vib., 76 (4), pp 529-541 (June 22, 1981) 13 figs, 10 refs

Key Words: Plates, Structural members, Sound transmission, Measurement techniques

With short duration impulsive signals used to provide the excitation, the vibration level difference across a T-junction of Perspex plates has been measured both as a function of frequency and angle of incidence. Problems associated with high velocity waves and relatively short path differences have been reduced or eliminated by suitable choice of material and geometry, and by use of spatial as well as temporal averaging. Problems associated with the dispersive nature of bending waves have been reduced by use of low pass filtering. Results are presented for point source excitation and comparison is made with plane wave excitation theory. In addition, plane wave excitation has been simulated by means of line averages of the plate response to a point source and these results are also presented and compared with the theoretical ones.

81-2427

Fatigue Design of Machine Elements Using the "Bagci Line" Defining the Fatigue Failure Surface Line (Mean Stress Diagram)

C. Bagci
Dept. of Mech. Engrg., Tennessee Tech. Univ., Cookeville, TN 38501, Mech. Mach. Theory, 16 (4), pp 339-359 (1981) 10 figs, 22 refs

Key Words: Fatigue life, Design techniques, Machinery components

Recently proposed fatigue failure surface line of Bagci that updates the Modified Goodman's, Gerber's, and Kececioglu's mean stress diagrams for the fatigue design of machine elements subjected to cyclic combined stresses having non-vanishing mean stress is presented. It fits the most recent fatigue data well and defines the two design zones in the mean stress diagram in one zone limiting the zone by the yield strength of the material, thus, providing a unified fatigue design equation for machine members. Its incorporation with the basic stresses according to different strength theories, such as the maximum distortion energy theory, maximum shearing stress theory, maximum total strain energy theory, and Coulomb-Mohr theory is given. The method of determining theoretical geometric stress concentration factor for combined state of stress – which is used along with the notch sensitivity of the material to determine a fatigue strength reduction factor – is also given. Applications of the Bagci line to the fatigue design of machine members are shown with numerical examples.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 2290, 2297, 2341, 2390, 2426)

81-2428

Mechanical-Aerodynamic Feedback in the Process of Sound Generation

S. Czarnecki, M. Czechowicz, and T. Sobol
Inst. of Fundamental Technological Res., Polish Academy of Sciences, 00-49 Warszawa, ul. Swietokrzyska 21, Poland, Arch. Acoustics, 5 (4), pp 289-304 (1980) 9 figs, 2 tables, 10 refs

Key Words: Sound generation, Vibration excitation

For many years phenomena of aerodynamic sound production have been known in the physical aspect, while a mathematical description of it is still insufficient. Therefore, investigations which have the increase of theoretical knowledge of this problem in view have been performed. These investigations are concerned mainly with the interactions between aerodynamic and acoustic phenomena. Investigation is made of the part played by mechanical vibrations in aerodynamic sound production. An attempt is made to explain the mutual aero-vibroacoustic interactions by means of feedback systems. Laboratory tests were carried out in order to perform the preliminary verification.

81-2429

Sound Decay in Reverberation Chambers with Diffusing Elements

K.H. Kuttruff
Institut f. Technische Akustik der Technischen Hochschule Aachen, D 51, Aachen, Germany, J. Acoust Soc. Amer., 69 (6), pp 1716-1723 (June 1981) 8 figs, 7 refs

Key Words: Reverberation chambers, Acoustic scattering

Sound scattering bodies are frequently used to improve diffusion in reverberation chambers and generally produce reverberation on their own. This effect is negligible at relatively low diffuser densities; in this range the effect of increasing diffusion prevails. At high densities of the scattering bodies, however, reverberation caused by the latter makes the usual reverberation formulae unapplicable. Between both

limiting cases there is an optimum range of diffuser density. This is calculated theoretically as well as determined by Monte-Carlo simulations.

81-2430

Nonlinear Equations of Acoustics, with Application to Parametric Acoustic Arrays

J.N. Tjotta and S. Tjotta
Appl. Res. Labs., Univ. of Texas at Austin, Austin, TX 78712, J. Acoust. Soc. Amer., 69 (6), pp 1644-1652 (June 1981) 3 figs, 25 refs

Key Words: Sound waves, Wave propagation, Acoustic arrays

The propagation and interaction of finite amplitude sound waves produced by a baffled piston source in a thermoviscous fluid are considered. Basic equations are derived and their ranges of validity established. This is used to relate some earlier works by others on nonlinear model equations in acoustics. Applications are made to the theory of parametric acoustic arrays, where the effects of nonlinear attenuation are discussed.

81-2431

Location of the Sources of Vibroacoustic Disturbances in Continuous Mechanical Objects in the Case of a Bottling Line

M. Andrzejewski and C. Cempel
Inst. of Technical Mechanics, Poznan Technical Univ., 69-965 Poznan, ul. Piotrowo 3, Poland, Arch. Acoustics, 5 (4), pp 275-288 (1980) 6 figs, 1 table, 3 refs

Key Words: Noise source identification, Industrial facilities

Methods of locating sources of vibroacoustic disturbances in continuous mechanical objects are presented. This problem is discussed in the case of the bottling line in a food industry enterprise. As a result of the investigations, the methods of investigation presented were found to be valuable. Their application in minimizing the acoustic activity of individual partial sources is also indicated.

SHOCK EXCITATION

(Also see No. 2301)

81-2432

Impulse Response Estimation with Underwater Explosive Charge Acoustic Signals

R.L. Dicus
Naval Ocean Res. and Dev. Activity, NSTL Station, MS, J. Acoust. Soc. Amer., 70 (1), pp 122-133 (July 1981) 5 figs, 1 table, 26 refs

Key Words: Underwater explosions, Impulse intensity, Linear systems

A procedure is presented for estimating the impulse response of a linear system from noise contaminated measurements of random input and output signals. The estimation requires ensemble averaged estimates of input and output noise spectra and a priori assumed spectra of the system function and input signal. A minimum mean-square-error estimator is derived and its theoretical signal-to-noise ratio is shown to be a slowly increasing function of the measured signal-to-noise ratios. The procedure is applied to a set of measured underwater explosive charge acoustic signals. For this application additional techniques are presented for synthesizing source replica signals and for accurately determining bubble pulse periods.

81-2433

An Analytic Method for Strong Motion Studies in Layered Media

H. Engin, A. Askar, and A.S. Cakmak
Dept. of Civil Engrg., Princeton Univ., Princeton, NJ 08544, Intl. J. Nonlin. Mechanics, 16 (2), pp 165-186 (1981) 7 figs, 14 refs

Key Words: Layered materials, Seismic excitation

An analytic method is presented for calculating strong motion spectra and response to arbitrary input in layered media. The method is based on the removal of secular terms at resonance of the equations with polynomial nonlinearity. The nonlinear effects are introduced by the frequency shifts calculated from the secular term according to the method by Millman and Keller. The procedure, through a convenient parametrization of the frequency, allows one to deal with linear equations. This possibility permits the extension of the method to multilayer systems by the use of transfer matrices.

VIBRATION EXCITATION

(Also see Nos. 2298, 2299, 2300)

81-2434

A Study on the Vortex Oscillator (2nd Report: Oscillatory Phenomena Occurring in a Confined Vortex Oscillator)

S. Takagi and Y. Yokoya

School of Energy Engrg., Toyohashi Univ. of Tech., Toyohashi 440, Japan, Bull. JSME, 24 (191), pp 802-808 (May 1981) 12 figs, 4 refs

Key Words: Oscillators, Vortex-induced vibration

A vortex oscillator, which has a double input vortex chamber and two conduit-capacity systems, is studied theoretically and experimentally. An oscillator with a single conduit-capacity system is also examined. A mathematical model of this type of oscillator is presented and its validity is examined by experiments. The stability of the equilibrium state of the system is discussed. The experimental data were found to be in good agreement with theoretical predictions.

81-2435

The Method of Modulated Amplitude and Its Use for the Study of Systems of Coupled Oscillators (La méthode de modulation d'amplitude et son application à l'étude des oscillateurs couplés)

M. Roseau

Laboratoire de Mécanique Théorique, Associé au C.N.R.S., Université Pierre-et-Marie-Curie, place Jussieu, 75230 Paris, J. de Mécanique, 20 (2), pp 199-217 (1981) 6 refs

(In French)

Key Words: Oscillators, Harmonic excitation

The behavior of a mechanical system made up of several weak nonlinear oscillators is discussed. Sufficient stability conditions are given; resonance cases and dying out of eigen modes also are dealt with.

81-2436

Combination Resonance in the Three Body Problem (Über eine Kombinationsresonanz im Dreikörperproblem)

E. Mettler

Z. angew. Math. Mech., 61 (1), pp 1-6 (Jan 1981) 3 figs, 6 refs

(In German)

Key Words: Celestial bodies, Vibration analysis

This paper deals with the close relationship between some parts of celestial mechanics and of the theory of vibrations. It shows that the secular perturbations in the planetary problem of three bodies, known for almost two centuries, represent a combination resonance with difference frequency in the sense of the modern theory of vibrations.

81-2437

Acoustic Coupling between Two Finite-Sized Spheres; n = 2 Mode

J.M. Reese and W. Thompson, Jr.

Pennsylvania State Univ., Dept. of Engrg. Science and Mechanics, University Park, PA 16801, J. Acoust. Soc. Amer., 69 (6), pp 1587-1590 (June 1981) 9 figs, 6 refs

Key Words: Mechanical impedance, Spheres

The modification of the radiation impedance load on a spherical source vibrating in the third or n = 2 axisymmetric mode, caused by the nearby presence of another equal sized sphere which is either vibrating in that same mode (in-phase or 180° out-of-phase) or is a perfect scatterer (rigid or soft), has been calculated. Plots of the normalized resistive and reactive components of the modified radiation impedance are presented as a function of the wavelength separation distance between the two spheres.

MECHANICAL PROPERTIES

DAMPING

(See Nos. 2440, 2496)

FATIGUE

(Also see Nos. 2303, 2304, 2343, 2367, 2368, 2369, 2373, 2374, 2375, 2427)

81-2438

Fatigue Notch Factors for Structural Details

P. Albrecht and S. Simon

Dept. of Civil Engrg., Univ. of Maryland, College

Park, MD 20742, ASCE J. Struc. Div., 107 (7), pp 1279-1296 (July 1981) 7 figs, 6 tables, 11 refs

Key Words: Fatigue life, Specifications, Bridges

The use of fatigue notch factors is proposed for specifying the relationship between the allowable stress range and the number of loading cycles. This is done by premultiplying the stress range with a fatigue notch factor which accounts for the severity of the detail's stress concentration. The method simplifies the manner in which fatigue specifications are written, and it conveys the idea of classification of details by severity of stress concentrations; it is most suitable for use in computer-aided analysis and design. The proposed equations for redundant load path structures give stress range values closer to those corresponding to the lower confidence limit at two standard deviations of the mean than the rounded off values in the specifications. The proposed equations for nonredundant load path structures are set at a uniform 5.5 standard deviations below the mean.

81-2439

Compression Fatigue Analysis of Fiber Composites

M.M. Ratwani and H.P. Kan

Northrop Corp., Hawthorne, CA, J. Aircraft, 18 (6), pp 458-462 (June 1981) 11 figs, 11 refs

Key Words: Fatigue life, Layered materials, Composite structures, Fiber composites

A macromechanics model, based on the delamination propagation between the plies of a composite laminate, has been developed for compression fatigue analysis of fiber composites. The model is based on the assumption that initial defects exist in composites between plies. These defects propagate due to the interlaminar stresses produced by applied fatigue loads. Existing compression fatigue data have been analyzed, using the model, and analytically predicted fatigue life compared with experimental data. Test data have been generated under constant amplitude loading on composite laminates with four different stacking sequences. Good correlations between experimentally observed fatigue data and analytical predictions have been found.

81-2440

Bending, Damping and Fatigue of Metals

G.F. Weissmann

Technical Staff, Bell Labs., Murray Hill, NJ 07974, Exptl. Mechanics, 21 (7), pp 257-260 (July 1981) 8 figs, 1 table, 12 refs

Key Words: Fatigue life, Damping effects, Metals

It has been shown that the plastic strain at the outside fiber of a rectangular beam subjected to uniform bending is significantly greater than the measured permanent set. Damping tests have been evaluated in terms of known strain distribution and it has been shown that the results are compatible with experimental data. The elastic limit, which corresponds to the fatigue limit, has been estimated using the results of damping tests. An excellent correlation between the predicted values of the fatigue limit and some conventionally determined fatigue data has been obtained.

81-2441

Cyclic Behavior of Class U Wheel Steel

Y.J. Park and D.H. Stone

Assoc. of American Railroads, Technical Ctr., Chicago, IL 60616, J. Engrg. Indus., Trans. ASME, 103 (1), pp 113-118 (Feb 1981) 8 figs, 5 tables, 5 refs

Key Words: Fatigue tests, Steel, Wheels

In order to evaluate the material properties of Class U wheel steel under cyclic loading, low-cycle fatigue tests were conducted at room temperature on specimens taken from the rim of the wheel. The test results show that Class U wheel steel experiences significant cyclic softening at lower strains, but cyclically hardens at larger strain levels. Due to the cyclic softening at lower strain levels, the steel will plastically deform, even at stresses of about one-half of the monotonic yield strength. Quantitative fatigue properties, which can then be used to predict accurate fatigue lives of various components of wheels under complex service environments, are also obtained from the low-cycle fatigue tests.

ELASTICITY AND PLASTICITY

(Also see No. 2430)

81-2442

Non-Linear Wave Propagation Solutions by Fourier Transform Perturbation

S.C. Chikwendu

Dept. of Mech. Engrg., Univ. of Nigeria, Nsukka, Nigeria, Intl. J. Nonlin. Mechanics, 16 (2), pp 117-128 (1981) 1 fig, 11 refs

Key Words: Wave propagation, Fourier transformation, Perturbation theory, Nonlinear theories

A Fourier transform perturbation method is developed and used to obtain uniformly valid asymptotic approximations of the solution of a class of one-dimensional second order wave equations with small nonlinearities. Multiple time scales are used and the initial-value problem on the infinite line is solved by Fourier transforming the wave equation and expanding the Fourier transform in powers of the small parameter. The nonlinearity involves only the first partial derivatives of the dependent variable and the determination of the leading approximation is reduced to the solution of a pair of coupled nonlinear ordinary differential equations in Fourier space. Examples are given involving a convolution nonlinearity and a Van-der-Pol nonlinearity.

81-2443

Spectral Analysis of Elastic Pulses Backscattered from Two Cylindrical Cavities in a Solid. Part I

S. Sancar and Y.-H. Pao
Dept. of Theoretical and Applied Mechanics, Cornell Univ., Ithaca, NY 14853, J. Acoust. Soc. Amer., 69 (6), pp 1591-1596 (June 1981) 1 fig, 10 refs

Key Words: Spectrum analysis, Elastic waves, Wave diffraction, Cavities

A series solution for the scattering of plane harmonic pressure waves from two cylindrical cavities in an elastic solid is derived in terms of cylindrical wavefunctions. The scattered waves are expressed as an infinite sum of various orders of scattering, the first order being the scattering of the incident wave by each of the two cavities, and each successive order being expressed in terms of the single cylinder scattering coefficients. The exact steady-state solution for the scattered radial stress is derived, which is also the power spectra of the scattered pulse due to an incident pulse of delta function in time. These results are simplified further for the case of backscattering at farfields.

81-2444

Spectral Analysis of Elastic Pulses Backscattered from Two Cylindrical Cavities in a Solid. Part II

S. Sancar and W. Sachse
Dept. of Theoretical and Applied Mechanics, Cornell Univ., Ithaca, NY 14853, J. Acoust. Soc. Amer., 69 (6), pp 1597-1609 (June 1981) 29 refs, 5 tables, 5 refs

Key Words: Spectrum analysis, Elastic waves, Wave diffraction, Cavities, Nondestructive tests, Failure detection

The eigenfunction solutions in Part I for the scattering of plane harmonic waves from two cylindrical cavities in an elastic solid is numerically evaluated for incident wave frequencies ranging from 0 - 10 MHz, and the power spectrum of the backscattered radial-stress pulse is calculated. These theoretical spectra, computed for a wide range of cavity radii, center-to-center separations, and incidence directions, are analyzed and interpreted. Spectral features are explained by the interference of various reflected and diffracted rays. Experimental backscattering spectra are obtained and compared with the theoretical results.

81-2445

Theoretical and Experimental Investigation of Stress Waves at a Junction of Three Bars

T.P. Desmond
Engrg. Mechanics Dept., SRI International, Menlo Park, CA 94025, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 148-154 (Mar 1981) 9 figs, 11 refs

Key Words: Wave propagation, Stress waves, Bars, Discontinuity-containing media

When a longitudinal stress wave impinges on a junction of three elastic bars (where two bars are collinear and a third is noncollinear to the others), six separate stress waves are produced. A longitudinal stress wave and a flexural wave are reflected back along the first bar, and a stress wave of each type is transmitted into the second and third bars. For the theoretical treatment of these waves, the simple one-dimensional theory is used to describe the propagation of longitudinal (or axial) waves, and the Timoshenko beam theory is used to describe the propagation of transverse (or bending) waves. The method of characteristics is used to transform the partial differential equations into total differential equations. The total differential equations are then solved by a forward differencing finite-difference scheme. For solution at the junction, the junction is modeled as a rigid-body element. Impact experiments were performed to verify the analysis, and agreement between theory and experiment is very satisfactory.

81-2446

Reflection, Refraction, and Absorption of Elastic Waves at a Frictional Interface: P and SV Motion

R.K. Miller and H.T. Tran
Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA 90007, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 155-160 (Mar 1981) 5 figs, 17 refs

Key Words: Interface: solid-solid, Elastic waves, Wave reflection, Wave refraction, Wave absorption, Coulomb friction

An approximate method of analysis is presented for determining the reflection, refraction, and absorption of obliquely incident planar time-harmonic P or SV waves at a frictional interface between dissimilar elastic solids. The solids are pressed together with sufficient pressure to prevent separation, and the angle of incidence is subcritical. General expressions for the amplitudes and phases of all reflected and refracted waves are developed in closed form for a broad class of models for bonding friction. Specific results are presented for the case of identical elastic solids bonded by Coulomb friction, as an example of application of the general approach.

81-2447

Acoustoelastic Effect of Rayleigh Surface Wave in Isotropic Material

M. Hirao, H. Fukuoka, and K. Hori
Faculty of Engrg. Science, Osaka Univ., Toyonaka, Osaka 560, Japan, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 119-124 (Mar 1981) 5 figs, 10 refs

Key Words: Wave propagation, Elastic waves

The acoustoelastic effect is investigated for the Rayleigh surface wave propagating in a homogeneous isotropic material. The initial deformations considered are uniform and nonuniform only in the direction of depth. The formulas for the velocity change versus the change in the applied static stress are derived in the first-order approximation.

81-2448

Elastic Wave Invariants for Acoustic Emission

W.J. Pardee
Rockwell Intl. Science Ctr., Thousand Oaks, CA, J. Acoust. Soc. Amer., 70 (1), pp 110-115 (July 1981) 1 fig, 8 refs

Key Words: Plates, Acoustic emission, Elastic waves

It is shown that there are four conserved properties of an elastic wave in an infinite isotropic plate: the energy, the two components of wave momentum parallel to the surface, and wave angular momentum normal to the surface. All four invariants are volume integrals of quadratic functions of the spatial (Eulerian) coordinates. The canonical energy-momentum density tensor and the orbital, spin, and total angular momentum density tensors are constructed and sufficient conditions for their conservation are demonstrated. A procedure for measuring the wave momentum of a surface wave is proposed. It is argued that these invariants are likely to be particularly useful characterizations of acoustic emission; e.g., from a growing crack. Experimental tests are proposed, and possible applications to practical monitoring problems described.

81-2449

Nonlinear Viscoelastic Behavior of a Cohesive Soil under Uniaxial Loading Conditions

S. Rafie and M.G. Sharma
Pennsylvania State Univ., University Park, PA, Rept. No. NSF/RA-800379, 98 pp (Sept 1980)
PB81-165573

Key Words: Soils, Axial excitation, Periodic excitation, Viscoelastic properties

The nonlinear viscoelastic behavior of a cohesive soil under uniaxial loading conditions was studied. A constitutive relationship based upon a multiple integral representation was developed. The time dependent parameters of this relation (kernal functions) were determined, performing uniaxial single-step creep tests on a specially developed test apparatus. The constitutive relationship was generalized for multi-step loading, as well as dynamic sinusoidal loading conditions. It was shown that the behavior of the material for multi-step loading conditions can be predicted by the results of the single-step tests.

81-2450

Third-Harmonic and Subharmonic Generation in General Media

F. Verheest
Instituut voor Theoretische Mechanika, Rijksuniversiteit Gent, Gent, Belgium, Wave Motion, 3 (3), pp 231-236 (July 1981) 1 fig, 9 refs

Key Words: Wave propagation

The problem of third-harmonic and subharmonic generation is treated for general media allowing for the presence of a negative-energy wave when necessary. Unequivocal conclusions are reached using coupled-mode theory based on two timescales and the principle of wave energy conservation.

81-2451

The Resonant Interaction Among Long and Short Waves

Y.-C. Ma

Fluid Mechanics Dept., TRW Defense and Space Systems Group, Redondo Beach, CA 90278, Wave Motion, 3 (3), pp 257-267 (July 1981) 8 refs

Key Words: Wave propagation

The resonant interaction among long and short waves is analyzed. The problem considered consists of two short wave envelopes with the same group speed resonating with a long wave. The phase speed of the long wave matches the group speed of the short waves. The problem is formulated by using perturbation expansions and stretched coordinates. The inverse scattering technique is applied to solve the evolution equations under some special conditions.

81-2452

Two-Dimensional Non-Linear Evolution Equations: The Derivation and the Transient Wave Solution

J. Engelbrecht

Dept. of Engrg. Math., The University, Newcastle upon Tyne, UK, Intl. J. Nonlin. Mechanics, 16 (2), pp 199-212 (1981) 3 figs, 1 table, 22 refs

Key Words: Sound waves, Wave propagation, Fluids

The general theory of two-dimensional evolution equations describing transient wave propagation in non-linear continuous media is presented The ray method is used and the two-dimensional evolution equations for plane and cylindrical wave-beams are obtained. The transient wave solutions are discussed briefly. A transformation of variables is proposed that permits the transformation of the two-dimensional evolution equation into a one-dimensional evolution equation with coordinate-dependent coefficients. A breakdown time analysis is carried out for this case. The dispersion relations for plane and cylindrical wave-beams are presented. The non-linear dispersion relation is obtained by making use of a series representation.

81-2453

Quasi-Static Magnetoelastic Vibration of an Infinite Ferromagnetic Plate in a Transverse Magnetic Field

N.C. Das, S.K. Bhattacharya, and S.N. Das

Dept. of Math., Jadavpur Univ., Calcutta, India, Mechanics Res. Comm., 8 (3), pp 153-160 (1981) 10 refs

Key Words: Plates, Magnetoelasticity, Resonant response

In this paper the critical value of the magnetic induction for resonance and elastic instability in an infinite plate with many triangular nodal lines has been determined under the action of a uniform or oscillating transverse magnetic field. Stability of the plate in an oscillating magnetic field has also been analyzed.

81-2454

Microanelasticity of a Vibrating Rod Containing Particles with Magnetic Moment

R.K.T. Hsieh and G. Vörös

Dept. of Mechanics, Royal Inst. of Tech., Stockholm, Sweden, Intl. J. Engrg. Sci., 19 (10), pp 1369-1376 (1981) 14 refs

Key Words: Rods, Vibreting structures, Magnetoelasticity

In this paper the vibrations of a rod containing local magnetic moments are generalized to include anelastic effects. Field equations are derived and a relation between the internal friction and the polar additional modulus is obtained.

81-2455

Flexural Waves in Rods Within an Axial Plastic Compressive Wave

L.H.N. Lee

Dept. of Aerospace and Mech. Engrg., Univ. of Notre Dame, Notre Dame, IN 46556, Wave Motion, 3 (3), pp 243-255 (July 1981) 5 figs, 6 refs

Key Words: Rods, Flexural waves

A stability concept in terms of the properties of an effective force field and an approach presented herein are employed to determine the growth of flexural waves in a rod subject to axial impact strong enough to produce plastic compressive strain. The concept and approach are developed for treating a class of problems of dynamics of elastic-plastic solids which may be called initial-value-eigenvalue problems or quasibifurcation problems. The theoretical results agree reasonably well with available experimental results.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see Nos. 2319, 2320, 2342)

81-2456

Shock Measurement with Non-Contacting Fiber Optic Levers

R.O. Cook, C.W. Hamm, and A. Akay
U.S. Natl. Inst. of Environmental Health Sciences, Res. Triangle Park, NC 27709, J. Sound Vib., 76 (3), pp 443-456 (July 8, 1981) 10 figs, 5 refs

Key Words: Vibration transducers, Proximity probes, Shock techniques, Shock response, High frequencies

The displacement, velocity, and acceleration performance limits of a noncontacting fiber optic lever vibration transducer are quantified. Performance characteristics are experimentally verified and measurements of displacement, velocity, and acceleration obtained from impacted plates are compared with those obtained by using conventional accelerometers. It is shown that all relevant transducer quantities; i.e., absolute maximum and minimum levels, dynamic range, and frequency response, lend themselves to quantification (or optimization) on a single graphic representation. The transducer is particularly useful for measuring high frequency shock parameters.

81-2457

A Non-Contacting Torque Sensor for the Internal Combustion Engine

W.B. Ribbens
Univ. of Michigan, Ann Arbor, MI, SAE Paper No. 810155

Key Words: Proximity probes, Torque, Internal combustion engines

An inexpensive, noncontacting sensor for the measurement of the quasi-average torque of an internal combustion engine is discussed. The quantity which is actually measured by this sensor is a low-pass filter transformation of instantaneous developed torque having a bandwidth of about 9 Hz. The paper explains the sensor concept in terms of specific mathematical models for the torque and engine dynamics.

81-2458

An Optical Device for Length Measuring the Distance Between a Measuring Point and a Reference Beam (Optische Längenmesseinrichtung zur Messung des Abstandes zu einem Bezugsstrahl)

W. Schwenzfeier and A. Winterstätter
Montanuniversität Leoben, Institut f. Verformungskunde und Hüttenmaschinen, A-8700 Leoben, Austria, Techn. Messen-TM, 48 (5), pp 187-190 (May 1981) 6 figs, 11 refs
(In German)

Key Words: Measuring instruments, Proximity probes

A measuring device is described which employs a noncontact sensor for length measurement. The device is moved along an optical beam on the surface of a workpiece and measures the distance between the support and the reference beam. A He-Ne laser, a single axis position sensing photodiode and a distance measuring device are used. The precision and resolution of the system are within the range of micrometers.

81-2459

Frequency Response of Interferometric Fiber-Optic Coil Hydrophones

J. Jarzynski, R. Hughes, T.R. Hickman, and J.A. Bucaro
Naval Res. Lab., Washington, DC 20375, J. Acoust. Soc. Amer., 69 (6), pp 1799-1808 (June 1981) 8 figs, 1 table, 20 refs

Key Words: Hydrophones, Interferometric techniques, Optical methods, Frequency response, Acoustic measuring instruments, Measuring instruments, Sound measurement

The frequency response of interferometric optical fiber hydrophones is examined theoretically and experimentally. The acoustic sensitivities of fiber coils are given for the range 100 Hz to 50 kHz. The observed dependence of the acoustic sensitivity on the sound frequency and coil orientation is explained in terms of an approximate theoretical model.

81-2460

Recursive Digital Filters for Real-Time Applications. Part 2: High-Pass Filters (Rekursive Digitalfilter für Echtzeitanwendungen. Teil 2: Hochpassfilter)

E. Schwieger

Institut f. Physik, GKSS Forschungszentrum Geesthacht GmbH, Reaktorstrasse 1, 2054 Geesthacht, Techn. Messen TM, 48 (6), pp 219-224 (June 1981) 13 figs, 7 refs
(In German)

Key Words: Filters, Digital filters, Real time spectrum analyzers

The design of digital high-pass filters using the bilinear z-transformation is presented and equations describing amplitude and phase of these filters are given. Some filters are calculated and examined in detail. The filter efficiency is demonstrated by test calculations and illustrated by two practical applications.

81-2461

The Dynamic Measurement of the Relative Displacement of Two Periodic Nearly Synchronous Phenomena (Die dynamische Erfassung des relativen Versatzes zweier periodischer nahezu synchroner Vorgänge)

M. Pandit
Universität Kaiserslautern, Fachbereich Elektrotechnik, Postfach 3049, 6750 Kaiserslautern, Germany, Techn. Messen TM, 48 (6), pp 225-228 (June 1981) 7 figs, 4 refs
(In German)

Key Words: Measuring instruments, Vibration detectors

In certain energy conversion or energy transmission systems it is essential to measure the momentary relative state of two periodic, nearly synchronous phenomena. A typical example of such a case is the measurement of the load angle; i.e., the angle between the stator and the rotor fields of a synchronous machine. A device is described which is capable of carrying out such measurement tasks on the basis of the above-mentioned example of the determination of the load angle. It is shown how this device can be used to detect the rapid oscillations of small amplitudes which are superimposed on the synchronous operation.

81-2462

Laser Interferometric Measurements of Very Small Vibration Amplitudes of the Order of Angstroms and Its Applications

D. Xianquan, Y. Zhongmin, and L. Wenlong
Natl. Inst. of Metrology, Beijing, China, Scientia Sinica, 25 (12), pp 1037-1041 (Dec 1980)
PB81-139990

Key Words: Vibration measurement, Small amplitudes, Interferometric techniques, Lasers

Two laser interferometric methods for measuring very small vibration amplitudes are described. One of these is an improved J sub 1max method. (J is the Bessel function of the first kind of the first order).

81-2463

Analysis of Forced Vibration with Reduced Impedance Method (Part 1. Introduction of Analytical Procedure)

A. Nagamatsu and M. Ookuma
Faculty of Engrg., Tokyo Inst. of Tech., Meguroku, Tokyo, Bull. JSME, 24 (189), pp 578-584 (Mar 1981) 16 figs, 3 tables, 4 refs

Key Words: Vibration analysis, Mechanical impedance

Forced vibrations of mechanical structures are analyzed by the reduced impedance method. A structure is divided into components, and the mechanical impedances of these components are calculated by the finite element method. These impedances are reduced and combined to get a united equation of the forced vibration. The forced vibrations of a plate, a box specimen and an actual cylinder block are analyzed by this method, changing the damping coefficient and the number of the finite elements of the components. The steady state vibration is measured under a harmonic exciting force, and the mechanical impedance is determined from the measured wave of the force and the acceleration. Calculated and experimental results agree.

81-2464

Taped Random Vibration Testing of Avionic Equipment

J. Devitt, R. Pokallus, and J. Popolo
Grumman Aerospace Corp., Bethpage, NY, TEST, 43 (4), pp 8-13 (Aug/Sept 1981) 5 figs, 1 table

Key Words: Testing techniques, Random vibration

A study program was undertaken by the authors to demonstrate the feasibility of using inexpensive stereo tape cassette recorders to provide random noise excitation for electro-

dynamic shaker systems. The 15-month test program was performed at the Grumman Avionic Test Facility on prototype as well as production flight hardware. The results of over 100 random vibration screening tests on production avionics clearly established the efficiency of synthesized random tape method.

DYNAMIC TESTS

(Also see No. 2328)

81-2465

Frequency Response Tester

H.P. Bakewell, Jr. and M.A. Johnson

Dept. of Navy, Washington, DC, U.S. Patent No. 4,236,401, 4 pp (Dec 2, 1980)

Key Words: Frequency response, Acoustic response, Test equipment and instrumentation

The patent relates to apparatus and method for determining the frequency response of an acoustic sensor of a line array embedded in an elastic material to a momentary force applied to the elastic material at any point thereof.

81-2466

An Experimental Study of the Dynamic Behavior of Soils

G.G-F. Luh

Ph.D. Thesis, Univ. of Wisconsin, Madison, WI, 148 pp (1980)

UM-8106513

Key Words: Soils, Sand, Clay soils, Dynamic shear modulus, Damping coefficients, Testing techniques

Dynamic shear modulus and damping capacity of soils are two important properties required in the analysis of a number of soil dynamics problems. An experimental study that is directed primarily toward improving our knowledge and understanding of these properties as a function of fundamental state and environmental parameters is undertaken. The investigation consists of two parts involving, respectively, sands and clays.

81-2467

Unique Test Capabilities at Sandia National Laboratories

J.C. Bushnell and D.C. Bickel

Sandia Natl. Labs., J. Environ. Sci., 24 (3), pp 11-14 (May-June 1981) 8 figs, 2 refs

Key Words: Test facilities, Vibration tests, Nondestructive tests

A comprehensive testing capability has evolved at Sandia National Laboratories over the last three decades. This capability is primarily dedicated to obtaining test response data to substantiate analytical methods employed at the Laboratories. Unique instrumentation and data transmission techniques have been developed to recover test data. Emphasis has been placed on expeditious processing of test results for correlation with the analytical processes. Numerous facilities address the general environments of acceleration, climate, shock, and vibration. Nondestructive testing includes acoustic emission detection, laser holography, ultrasonics, and radiography. More specific testing exists in the fields of aerodynamics, materials characterization, radiation effects, and energy research.

DIAGNOSTICS

(Also see Nos. 2444, 2475)

81-2468

Use of Quasi-Random Vibration Facility to Reduce No Defect Rates in Air Force Avionics

A.L. Lena

Hughes Aircraft Co., Culver City, CA, J. Environ. Sci., 24 (3), pp 17-22 (May-June 1981) 4 figs, 4 tables, 9 refs

Key Words: Diagnostic techniques, Test facilities

The paper describes the results of a field experiment to investigate the effectiveness of using environmental conditioning, namely quasi-random vibration, as a diagnostic tool to reduce No Defect (ND) rates of Air Force avionic equipment. In particular, a prototype of a quasi-random, multi-axis vibration facility was installed in the intermediate maintenance shop of the 49th Component Repair Squadron at Holloman AFB, New Mexico, for a period of 6 months to determine its effectiveness in reducing ND rates for three selected line replaceable units (LRUs). The resulting data will be presented in terms of individual LRU test results, study program influence on ND rate and lessons learned. Conclusions and recommendations regarding this and future programs of this type are also presented.

81-2469

Acoustic Emission: A Means of Measuring Crack Growth at Elevated Temperatures

A. Arora and K. Tangri

Rockwell Intl. Science Ctr., Thousand Oaks, CA 91360, Exptl. Mechanics, 21 (7), pp 261-267 (July 1981) 12 figs, 1 table, 18 refs

Key Words: Diagnostic techniques, Acoustic emission, Crack detection

The purpose of this investigation is to present an alternative approach to measuring slow crack growth at elevated temperatures using acoustic-emission technique and to show how acoustic-emission signal processing can be used to reflect the fracture behavior of the material.

81-2470

Application of a Structural-Acoustic Diagnostic Technique to Reduce Boom Noise in a Passenger Vehicle

C.A. Joachim, D.J. Nefske, and J.A. Wolf, Jr.

Engrg. Dept., General Motors Holden's Ltd., Port Melbourne, Australia, SAE Paper No. 810398

Key Words: Automobile noise, Interior noise, Noise source identification, Diagnostic techniques, Engine mounts

An acoustic finite element capability and a Fourier analysis capability are employed to identify the structural areas that cause boom noise in a vehicle. The noise occurs in the 127-140 Hz frequency range and results from the forces transmitted to the body structure from the vibration of the engine on its mounts. The phenomenon is diagnosed as being caused by panel vibrations exciting the second longitudinal acoustic resonance of the passenger compartment.

81-2471

A Diagnosis Method for Linear Stochastic Systems with Parametric Failures

K. Watanabe, T. Yoshimura, and T. Soeda

Dept. of Aeronautical Engrg., Kyushu Univ., Fukuoka, Japan, J. Dyn. Syst., Meas. and Control, Trans. ASME, 103 (1), pp 28-35 (Mar 1981) 4 figs, 20 refs

Key Words: Diagnostic techniques, Failure detection, Filters

A method of failure diagnosis for discrete-time stochastic systems with some parametric failures is proposed. It is assumed that the time instances of failure occurrence and the dynamic behaviors of failure parameters cannot be estimated in advance. The idea of Two-Filters is utilized as the filter construction for the diagnosis system. The new feature of the approach is to use a modified adaptive extended Kalman filter which estimates system parameters and states simultaneously under the failure mode. The a[illegible]ve mechanism of this filter is based on hypothesis tests for the innovation and for the estimation errors of system parameters, and modifies the filter gains if the hypothesis is rejected. In addition, a discriminator, which uses the trace value of the approximate local sensitivity, is developed in order to help the operator's tasks. Experimental results indicate that the proposed method on the failure diagnosis is effective for several numerical examples.

81-2472

Adaptive Noise Cancelling and Condition Monitoring

G.K. Chaturvedi and D.W. Thomas

Dept. of Electronics, Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 76 (3), pp 391-405 (July 8, 1981) 12 figs, 2 tables, 13 refs

Key Words: Monitoring techniques, Filters

When mechanical signature analysis methods are applied to the detection of faults within a complex machine, one is often confronted with a situation in which the diagnostic signal is embedded in a background noise. Coherent filtering techniques are of help in improving the signal to noise ratio (SNR) only when a synchronizing signal is available; on the other hand, the adaptive noise cancelling (ANC) technique can be successfully applied to increase the SNR even in those situations where a synchronization signal is not available. ANC is a form of optimal filtering in which use is made of an auxiliary or a reference signal. It is shown that the statistical and spectral analyses techniques which fail to detect and diagnose faults because of a poor SNR can be made effective by using an ANC technique. The expression for the signal to noise density ratio at the output of the noise canceller is derived for a simplified model of a machine.

81-2473

Interference of Corner Reflected and Edge Diffracted Signals for a Surface-Breaking Crack

J.D. Achenbach and A.N. Norris

The Technological Inst., Northwestern Univ., Evanston, IL, J. Acoust. Soc. Amer., 70 (1), pp 165-171 (July 1981) 6 figs, 5 refs

Key Words: Transducers, Wave diffraction, Cracked media

Backscatter of time-harmonic longitudinal waves from a surface-breaking crack is investigated in the high-frequency

range. It is assumed that the distance of the transducer to the crack is large as compared to the crack depth, and that the incident rays are normal to the crack edge. The crack length is assumed much greater than its depth. A two-dimensional model for the transducer is considered. In the time domain, the first and second received signals are the edge-diffracted signal and the corner-reflected signal, respectively. These signals are analyzed in the frequency domain, by using the uniform asymptotic theory of diffraction. The response of the transducer due to the interference of the two signals is calculated. It is shown that the transducer's response is a sensitive function of its position.

BALANCING

81-2474

Demonstration of a Unified Approach to the Balancing of Flexible Rotors

M.S. Darlow, A.J. Smalley, and A.G. Parkinson
Machinery Dynamics Section, Mechanical Tech., Inc., Latham, NY 12110, J. Engrg. Power, Trans. ASME, 103 (1), pp 101-107 (Jan 1981) 9 figs, 7 tables, 12 refs

Key Words: Rotors, Flexible rotors, Balancing techniques, Modal balancing technique, Influence coefficient technique

A flexible rotor balancing procedure, which incorporates the advantages and eliminates the disadvantages of the modal and influence coefficient procedures, has been developed and implemented. This new procedure, referred to as the Unified Balancing Approach, has been demonstrated on a supercritical power transmission shaft test rig. The test rig was successfully balanced through four flexural critical speeds with a substantial reduction in effort as compared with the effort required in modal and influence coefficient balancing procedures. A brief discussion of the Unified Balancing Approach and its relationship to the modal and influence coefficient methods is presented. A series of tests which were performed to evaluate the effectiveness of various balancing techniques are described. The results of the Unified Balancing Approach tests are presented and discussed. These results confirm the superiority of this balancing procedure for the supercritical shaft test rig in particular and for multiple-mode balancing in general.

MONITORING

81-2475

Acoustic Emission Flaw Relationship for In-Service Monitoring of Nuclear Pressure Vessels

P.H. Hutton and R.J. Kurtz
Battelle Pacific Northwest Labs., Richland, WA, Rept. No. CONF-8006142-1, 8 pp (1980)
PNL-SA-8691

Key Words: Diagnostic techniques, Acoustic detection, Pressure vessels, Nuclear reactor components

Acoustic emission (AE) testing has the potential of being a valuable NDI method with capability for continuous monitoring, high sensitivity, and remote flaw location. Tests of the method were carried out on ASTM A533 Grade B, Class 1 steel. Crack growth AE signals could be recognized. An AE/fracture mechanics relation was developed for flaw interpretation. Two intermediate vessel tests at ORNL under the HSST program were analyzed.

81-2476

On-Line Hole Quality Evaluation for Drilling Composite Material Using Dynamic Data

T. Radhakrishnan and S.M. Wu
Mech. Engrg. Dept., Univ. of Wisconsin, Madison, WI 53706, J. Engrg. Indus., Trans. ASME, 103 (1), pp 119-125 (Feb 1981) 6 figs, 2 tables, 5 refs

Key Words: Drills, Monitoring techniques, Dynamic data system technique

Aircraft manufacturing involves the drilling of a large number of holes for structural joints. The life and proper functioning of the joint can be critically affected by the quality of the hole which generally deteriorates with drill wear. In the use of composite material for the aircraft structure, the "lamination frequency," associated with the laminated fiber of the material, can be considered to represent the waviness of the hole surface (an aspect of hole quality). The variance associated with this frequency, present in the dynamic nature of the drilling thrust and the hole surface profile, was found to change with the use of the drill. This study presents the possibility of using this change in the lamination frequency content of the drilling thrust for on-line monitoring of the drill condition, through analysis by the Dynamic Data System technique.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see Nos. 2442, 2443, 2444, 2497, 2498)

81-2477

Free and Forced Vibrations of a Linear Non-Conservative System with Multiple Eigenvalues

W. Kliem

Danmarks Ingeniörakademi, Maskinafdelingen, Akademivej, bygning 58, 2800 Lyngby, Denmark, Z. angew. Math. Mech., 60 (11), pp 569-575 (Nov 1980) 11 refs

Key Words: Eigenvalue problems

The paper shows the derivation of the response of a linear system governed by the equation $A\ddot{q} + B\dot{q} + Cq = Q(t)$, in which the square matrices A, B and C are real and constant, but not necessarily symmetric or positively definite. In addition, the special case of multiple eigenvalues with an insufficient number of eigenvectors occurs. The theory is an extension of the work by Wahed and Bishop, which is limited to distinct eigenvalues.

81-2478

Eigenproblems Associated with the Discrete LBB Condition for Incompressible Finite Elements

D.S. Malkus

Dept. of Math., Illinois Inst. of Tech., Chicago, IL 60616, Intl. J. Engrg. Sci., 19 (10), pp 1299-1310 (1981) 16 refs

Key Words: Eigenvalue problems, Stability, Fluid mechanics, Finite element technique

The basic stability condition for mixed/Lagrange multiplier variational principles in incompressible media problems is the LBB condition. It plays an essential role in determining whether or not the problem is well-posed and governs the choice of finite elements in the discretization. This paper examines the discrete eigenstructure of a well-known Lagrange multiplier formulation for linear elasticity or Stokes-flow. It shows how the weak incompressibility constraint is reflected in the elementary divisor structure of the eigenproblem whose solution determines the finite element approximation to the natural modes. In this context the discrete LBB condition can be seen to be a condition determining the limiting disposition, as the mesh parameter decreases, of a matrix pencil with infinite eigenvalues. Pure pressure modes and the load vectors required to transmit them are paired in cyclic subspaces of the infinite eigenspace. This pairing can be related to a well-known heuristic interpretation of the LBB condition. The relationship between the natural mode eigenproblem and the eigenproblems which determine the norm of the inverse of the discrete operator of a static or steady-flow problem is described. Finally, because of the equivalence between classes of mixed and penalty formulations, it is shown that these results apply to penalty/reduced integration finite element methods.

81-2479

On the Stability of Equilibrium Paths Associated with Autonomous Systems

K. Huseyin

Dept. of Systems Design, Univ. of Waterloo, Waterloo, Ontario, N2L 3G1, Canada, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 183-187 (Mar 1981) 7 refs

Key Words: Stability methods

The postcritical behavior and stability distribution on the equilibrium paths emanating from a divergence point associated with an autonomous system are studied within a state-space formulation. The analysis concerning the stability of equilibrium paths is based on the eigenvalues of the Jacobian evaluated at arbitrary equilibrium points in the vicinity of a critical point. Explicit conditions of stability and instability concerning the initial and postcritical paths are obtained through a perturbation approach. It is shown that at an asymmetric point of bifurcation an exchange of stabilities between two paths occurs in complete analogy with conservative systems. Similarly, a symmetric point of bifurcation involves a postcritical path which is totally stable (unstable) if the initial path is unstable (stable).

81-2480

Stability Theorems for Multidimensional Linear Systems with Variable Parameters

S.K. Shrivastava

Structures and Mechanics Div., L.B. Johnson Space Ctr., NASA, Houston, TX 77062, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 174-176 (Mar 1981) 3 refs

Key Words: Stability, Linear systems, Variable material properties, Lyapunov's method

Two equivalent theorems governing stability of multidimensional linear systems with variable parameters are derived which generalize some of the existing stability theorems. Illustrations include damped, gyroscopic, circulatory systems with varying parameters.

81-2481

A Perturbation Analysis of Fluid-Structure Interactions in a Model Test System

K.M. Kalumuck and P.W. Huber

Dept. of Mech. Engrg., Massachusetts Inst. of Tech., Cambridge, MA 02139, J. Appl. Mechanics, Trans. ASME, 48 (1), pp 7-14 (Mar 1981) 12 figs, 2 tables, 8 refs

Key Words: Interaction: structure-fluid, Fluid-filled containers, Perturbation theory

A perturbation analysis of fluid-structure interactions in a model test system of controlled flexibility excited by a complex hydrodynamic transient is presented. The analysis demonstrates the important features of the perturbation method and its implementation. Comparison of predictions with experiment provides a test of the analytical procedure and its underlying assumptions. The results illustrate the important effect of transient liquid mass redistribution on the flexible system response.

81-2482

On Relaxation Oscillations Governed by a Second Order Differential Equation for a Large Parameter and with a Piecewise Linear Function

K.K. Anand

Ph.D. Thesis, New York Univ., 92 pp (1980)
UM 8110712

Key Words: Oscillation, Differential equations

This thesis deals with the relaxation oscillations governed by a nonlinear second order differential equation.

81-2483

Vibration of Complex Structures: The Modal Constraint Method

J.G.M. Kerstens

Space-Div., Fokker B.V., Schiphol-Oost, The Netherlands, J. Sound Vib., 76 (4), pp 467-480 (June 22, 1981) 4 figs, 4 tables, 15 refs

Key Words: Natural frequencies, Modal constraint method, Complex structures

A method is described for establishing the natural frequencies of an arbitrary structure with arbitrary supports. The method is based on the modal constraint technique described in a previous paper. Weinstein's theory for the intermediate problem can be regarded as equivalent to the La.. ngian multiplier method; i.e., both methods result in the same eigenvalue equations. Weinstein's theory deals with modifications of base differential operators whereas the Lagrangian multiplier method deals with modifications of base energy functionals. The modal constraint technique is an extension of Weinstein's theory, or in energy terms the generalized Fourier expansion of the Lagrangian multiplier. The merits of this method lie in the fact that the eigenvalues and eigenfunctions of structures are used as base structures. The coupling of these structures are taken into account by Lagrangian generalized forces of the constraint acting on the base structures. Some examples are given and the results compared with known solutions.

81-2484

Analytical Calculation of Nonlinear Natural Frequencies by Means of Canonical Transformation (Analytische Berechnung nichtlinearer Eigenschwingungen durch kanonische Transformation)

H.-D. Schräpel

Institut f. Mechanik (Bauwesen), Pfaffenwaldring 7, 7000 Stuttgart 80, West Germany, Z. angew. Math. Mech., 61 (1), pp 29-40 (Jan 1981) 8 figs, 11 refs (In German)

Key Words: Natural frequencies, Nonlinear response, Transformation techniques

A new analytical method for approximate computing of nonlinear free vibrations is expanded. The equations of motion are decoupled by the known linear transformation in the linear terms. The canonical transformation can be computed slightly by approximation provided the coupling terms are not too large.

81-2485

A Combined Time and Frequency Domain Method for Model Reduction of Discrete Systems

C. Hwang, Y.-P. Shih, and R.-Y. Hwang

Dept. of Chemical Engrg., Natl. Cheng Kung Univ. Tainan, Taiwan, China, J. Franklin Inst., 311 (6), pp 391-402 (1981) 2 figs, 40 refs

Key Words: Time domain method, Frequency domain method, Reduction methods

A new combined time and frequency domain method for the model reduction of discrete systems in z-transfer functions is presented. The advantages of the proposed method are that both frequency domain and time domain characteristics of the original systems can be preserved in the reduced models, and the reduced models are always stable provided the original models are stable.

81-2486

A Describing Function for Dynamic Forces in Single-Degree-of-Freedom Mechanisms

R.R. Allen and D.M. Rozelle

Mechanics and Structures Dept., School of Engrg. and Appl. Science, Univ. of California, Los Angeles, CA 90024, J. Dyn. Syst. Meas. and Control, Trans. ASME, 102 (4), pp 240-246 (Dec 1980) 9 figs, 1 table, 15 refs

Key Words: Mechanisms, Single degree of freedom systems, Describing function approach, Spectrum analysis, Time domain method

In a single degree-of-freedom mechanism, a generalized force is produced by elastic, dissipative, and inertial effects. This force may be expressed as a power series in the mechanism's generalized velocity where the coefficients are functions of the generalized displacement. Approximating the coefficients by their Fourier series expansions produces a describing function which is rapidly convergent and provides substantial computational and analytical advantages over using the exact equations. This describing function permits efficient time-domain simulation of mechanism dynamics and produces an analytical expression for the spectral content of the mechanism dynamic force. Generation and application of the describing function is illustrated by a numerical example.

81-2487

Epstein Profiles and the Riemann P-Functions

C.R.A. Rao

School of Mathematical Sciences, The Flinders Univ. of South Australia, Bedford Park, Australia, Wave Motion, 3 (3), pp 237-241 (July 1981) 4 refs

Key Words: Power series method

The analytical implications of the direct power series solutions of the second order wave equation and the fourth order elastodynamic equations for inhomogeneous media represented by the Epstein profiles are examined.

81-2488

Crash Data Analysis and Model Validation Using Correlation Techniques

J. Jovanovski

Ford Motor Co., SAE Paper No. 810471

Key Words: Collision research (automotive), Data processing, Correlation techniques

A quantitative comparison technique for evaluating similarities between sets of data resulting from a common random process is presented. The normalized integral square error (NISE) criterion is derived using correlation techniques and is applied to deceleration-time histories obtained from six vehicle crash tests in an attempt to relate the vehicle response to the crash event. Two sets of data resulting from computer simulations of vehicle crashes are also analyzed to determine if NISE is usable as a computer model validation tool. A possible graphical method for simplifying the calculation of NISE is presented.

81-2489

Method of R-Functions and Its Application to Analysis of Vibrations of Plates and Other Structures

A. Waberski

Dept. of Math. and Physics, Silesian Technical Univ., Gliwice, Poland, Shock Vib. Dig., 13 (7), pp 11-14 (July 1981) 30 refs

Key Words: Method of R-functions, Boundary value problems, Plates, Reviews

The method of R-functions is a new method to solve value boundary problems of complex form in mathematical physics. This method also has wide application to analysis of vibrations of plates and other complex structures. The development of this method in recent years is presented in this paper.

81-2490

An Exact Condensation Procedure for Chain-Like Structures Using a Finite Element-Transfer Matrix Approach

V.H. Mucino and V. Pavelic

Dept. of Mech. Engrg., Univ. of Wisconsin, Milwaukee, WI 53201, J. Mech. Des., Trans. ASME, 103 (2), pp 295-303 (Apr 1981) 6 figs, 25 refs

Key Words: Elastic media, Reduction methods, Finite element technique, Transfer matrix method

The main objective of this study is to describe a new scheme to carry out the static or dynamic analysis of elastic systems using a combined Finite Element-Transfer Matrix Approach.

The proposed scheme offers the advantage of automatic matrix size reduction without having to truncate degrees of freedom, and preserving the strain and kinetic energy throughout the condensation. Although limited to chain-like elastic systems, the method is generalized to non-repetitive configurations with substructures having intermediate active degrees of freedom.

81-2491

Finite Element Analysis of High-Speed Flexible Mechanisms

W.L. Cleghorn, R.G. Fenton, and B. Tabarrok
Dept. of Mech. Engrg., Univ. of Toronto, Toronto, Ontario, Canada M5S1A4, Mech. Mach. Theory, 16 (4), pp 407-424 (1981) 6 figs, 9 refs

Key Words: Mechanisms, Four bar mechanisms, Finite element technique

A procedure is presented for determining the governing equations of a mechanism with physically undamped flexible links and distributed mass, operating at a prescribed input rotational speed. The procedure is illustrated by a detailed analysis of a planar 4-bar angular function generating mechanism. The set of governing equations for the deflections about the rigid body trajectory of mechanism members is derived using the Lagrange equation.

81-2492

Dynamic Force Analysis of Planar Mechanisms

R.J. Williams and S. Rupprecht
Control Data Corp., Minneapolis, MN, Mech. Mach. Theory, 16 (4), pp 425-440 (1981) 12 figs, 1 table, 9 refs

Key Words: Mechanisms, Computer-aided techniques

A computer-oriented procedure for solving the dynamic force analysis problem for general planar mechanisms is presented. The procedure is based upon writing three equations of equilibrium for each link in the mechanism from free body diagrams. Inertia forces are included using d'Alembert's principle. A technique is shown for automatically reformulating these equations into matrix form so the joint constraint forces and the driving input force or torque can be readily solved for using Gaussian elimination. This computer-oriented technique operates directly on the equations written from body diagrams.

MODELING TECHNIQUES

(Also see No. 2336)

81-2493

Dynamic System Response Technology Transfer via Computer Modeling

L.D. Mitchell and R.G. Mitchiner
Dept. of Mech. Engrg., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Mech. Des., Trans. ASME, 103 (2), pp 281-288 (Apr 1981) 5 figs, 8 tables, 11 refs

Key Words: Mathematical models, Periodic response, Multi-degree of freedom systems, Mobility method, Impedance technique

Traditionally the mechanical engineering design area of the mechanical engineering discipline has concerned itself with static design concepts. Recently, many university mechanical engineering curricula have placed a dynamics sequence in the mechanical design course path. This has had two results. First, the former graduates having little background in dynamic design concepts need to have a technology transfer effort focused upon them. Second, the current university student finds the understanding of highly mathematical, multiple degree-of-freedom models of real systems almost incomprehensible. This paper presents a proposed partial solution to the technology transfer problem above. A computer modeling program has been developed that computes the steady-state response of a multi-degree-of-freedom system. Magnitude and phase of the response is graphically presented for combinations of masses, stiffnesses, viscous dampers, and/or structural dampers in any interconnection scheme. The algorithm has been used to model real-world engineering problems that would normally elude the undergraduate student and many practicing engineers. These same modeling efforts can be used to stimulate the practicing engineer to relate to these solutions and their real-world significance.

NUMERICAL METHODS

81-2494

Calculating Natural Frequencies with Extended Tuplin's Method

C.C. Wang
Central Engrg. Lab., FMC Corp., Santa Clara, CA 95052, J. Mech. Des., Trans. ASME, 103 (2), pp 379-386 (Apr 1981) 6 figs, 21 refs

Key Words: Torsional vibration, Natural frequencies, Frequency equation, Polynomial analysis

An efficient numerical procedure is described which yields the eigenvalue of a lumped mass torsional vibration directly from the frequency equation of the system. Special characteristics of Tuplin's frequency equation allow all eigenvalues to be easily located and accurately evaluated from the frequency polynomial. In contrast to the general belief that extracting roots of polynomials is less efficient than matrix reduction methods, this paper demonstrates that the direct solution competes favorably with the modern eigenvalue routines such as QR and tridiagonal methods in torsional vibration problems.

81-2495

Simultaneous Iteration Procedures for High Order General Eigenvalue Problems (Simultane Iterationsverfahren für grosse allgemeine Eigenwertprobleme)

H.R. Schwarz

Universitat Zurich, Freiestr. 36 CH-8032 Zurich, Schweiz, Ing. Arch., 50 (5), pp 329-338 (1981) 1 fig, 1 table, 21 refs

(In German)

Key Words: Iteration, Eigenvalue problems

For the computation of the p smallest eigenvalues and the corresponding eigenvectors of $Ax = \lambda Bx$ with symmetric and sparse matrices A and B and with a positive definite matrix B of high order possible variants of the simultaneous Rayleigh quotient iteration methods are presented and discussed. The method of the simultaneous coordinate overrelaxation and of conjugate gradients have the advantageous property to use A and B unchanged and are indeed very efficient in certain applications.

81-2496

Reduction and Iteration for Computing the Eigenvalues of Discrete Damped Vibrating Systems (Reduktion und Iteration zur Eigenwertberechnung Diskret Gedämpfter Schwingungssysteme)

P. Ruge and J. Schneider

Lehrstuhl f. Mechanik und Festigkeitslehre im Mechanikzentrum, TU Braunschweig Pockelsstrasse 4, D-3300 Braunschweig Bundesrepublik Deutschland, Ing. Arch. 50 (5), pp 297-313 (1981) 5 figs, 4 tables, 12 refs

(In German)

Key Words: Multi degree of freedom systems, Continuous systems, Viscous damping, Reduction methods, Iteration

The computation of multi-degree-of-freedom- and continuous systems with discrete viscous damping requires a very high numerical effort. For discrete systems iteration methods are presented which start from the special proportionally damped case. For Kirchhoff's plate a mixed functional is evaluated in which the displacements and velocities are taken to be independent. This method allows an accurate elimination of the displacement parameters and reduces the order of the corresponding algebraic eigenvalue problem.

STATISTICAL METHODS

81-2497

Improved Statistical Linearization for Analysis and Control of Nonlinear Stochastic Systems: Part 1: An Extended Statistical Linearization Technique

J.J. Beaman and J.K. Hedrick

Dept. of Mech. Engrg., Univ. of Texas at Austin, Austin, TX 78712, J. Dyn. Syst., Meas. and Control, Trans. ASME, 103 (1), pp 14-21 (Mar 1981) 3 figs, 1 table, 28 refs

Key Words: Statistical analysis, Statistical linearization

A practical method of improving the accuracy of the Gaussian statistical linearization technique is presented. The method uses a series expansion of the unknown probability density function which includes up to fourth order terms. It is shown that by the use of the Gram-Charlier expansion a simple generating function can be derived to evaluate analytically the integrals required. It is also shown how simplifying assumptions can be used to substantially reduce the required extra equations, e.g. symmetric or assymetric and single input nonlinearities. It is also shown that the eigenvalues of the statistically linearized system can be used to estimate the stability and speed of response of the nonlinear system.

81-2498

Improved Statistical Linearization for Analysis and Control of Nonlinear Stochastic Systems: Part II: Application to Control System Design

J.J. Beaman and J.K. Hedrick

Dept. of Mech. Engrg., Univ. of Texas at Austin, Austin, TX 78712, J. Dyn. Syst., Meas. and Control,

Trans. ASME, 103 (1), pp 22-27 (Mar 1981) 13 figs, 2 tables, 13 refs

Key Words: Statistical analysis, Statistical linearization, Control equipment

Using the techniques of Gaussian statistical linearization and the extension given in Part I, this paper describes the synthesis of linear feedback controllers for nonlinear stochastic systems. The method used is that of pole placement of the statistically linearized "eigenvalues." The technique is described in terms of a design example, a position servomechanism with backlash, it is shown that for this type of system the standard Gaussian method works well for large input noise levels but can lead to an unstable design for low input levels. The extended fourth cumulant method is satisfactory for both cases studied. The results of the analysis are compared to Monte Carlo digital simulations to test their accuracy.

81-2499

An Approach to the Theoretical Background of Statistical Energy Analysis Applied to Structural Vibration

J. Woodhouse

Topexpress Ltd., 1 Portugal Pl., Cambridge, UK, J. Acoust. Soc. Amer., 69 (6), pp 1695-1709 (June 1981) 7 figs, 13 refs

Key Words: Statistical energy analysis, Vibration analysis, Rayleigh method

Rayleigh's classical approach to the study of vibration of systems having a finite number of degrees of freedom is applied to the problem of coupling of subsystems in a complicated structure, in order to probe the regions of applicability of the approach to vibration analysis usually known as statistical energy analysis (SEA). The classical method has advantages of simplicity and rigor over previous approaches to the background of SEA in certain cases, and provides extensions and simplifications in several areas of the theory. It also suggests modifications to SEA modeling strategy depending on the type of coupling involved, even when that coupling is weak, so that earlier analyses might be thought to apply.

PARAMETER IDENTIFICATION

81-2500

Identification of Linear Discrete Dynamic Subsystems

C.E. Kim

Ph.D. Thesis, Univ. of Pittsburgh, 248 pp (1980) UM 8112700

Key Words: System identification techniques

In this dissertation, the identification problem for linear discrete dynamic subsystems is studied. The objective is to establish a foundation for the solution of the general subsystem identification problem in such a way that the results can be applied to the distributed identification or estimation of a large-scale system. The problem is formulated for several classes of systems by specifying for each class: the study subsystem, the model structure, the experimental condition (the residual system, interconnection structure and external input condition), and the identification method. The main efforts are directed towards investigating the identifiability condition (especially for deterministic subsystems) and determining a consistent identification technique (especially for stochastic subsystems).

81-2501

Approximated Error Analysis in Modal Synthesis – the Results within System Analysis and System Identification (Angenäherte Fehlerermittlung für Modalsynthese – Ergebnisse innerhalb der Systemanalyse und Systemidentifikation)

H.G. Natke

Universität Hannover, Curt-Risch-Institut, Callinstrasse 32, Hannover, W. Germany, Z. angew. Math. Mech., 61 (1), pp 41-53 (Jan 1981) 2 figs, 4 tables, 12 refs

(In German)

Key Words: Error analysis, Modal synthesis, Substructuring methods, System identification techniques

Modal synthesis is based on substructure results and serves as a method for investigating complex vibrating structures. An approximated error analysis is presented for multidegree-of-freedom systems which is based on dynamic condensation and does not need the knowledge of the modal magnitudes of the truncated degrees-of-freedom. The procedure is applicable to each regular transformation in generalized coordinates. Examples show the quality of the approximated errors for a disadvantageous transformation.

MOBILITY/IMPEDANCE METHODS

(See No. 2493)

COMPUTER PROGRAMS

(Also see No. 2342)

81-2502

Development and Evaluation of the CRASH 2 Pro-

gram for Use under European Conditions

I.S. Jones and P.W. Jennings
Oxford Road Accident Group, Dept. of Engrg. Sci., Univ. of Oxford, SAE Paper No. 810473

Key Words: Computer programs, Collision research (automotive)

This paper reports recent work undertaken by the Oxford Road Accident Group to improve the utility of the CRASH 2 (Calspan Reconstruction of Accident Speeds on the Highway) program. To provide reliable figures as to the utility of the program under European conditions a representative sample of accidents has been reconstructed using CRASH 2: the sample consisted of 200 accidents investigated on-scene and 200 accidents investigated on a 48 hour follow-up basis. Results are presented which give the proportion of accidents that could be successfully CRASHed together with the reasons for not running CRASH.

81-2503

Vehicle Crash Simulation Using Hybrid Model

I. Hagiwara, Y. Sasakura, T. Nakagawa, and Y. Kajio
Nissan Motor Co., Ltd., SAE Paper No. 810476

Key Words: Computer programs, Finite element technique, Lumped parameter method, Collision research (automotive)

The analysis of automotive collisions was first conducted by a lumped-mass method, although it has some shortcomings; e.g., it is difficult to make models and it is inappropriate for three-dimensional analysis. Consequently, a finite element method is also presently in use. From the finite element method currently in use, for the purpose, however, a practical level of analysis duration and deformation analysis cannot be expected. Therefore, a hybrid program called "FEMASS" has been developed which is a combination of the lumped-mass method and the finite element method programs. Some vehicle hybrid models made by this program have been utilized in the analysis of rear-end collisions. The resultant simulations reveal that the acceleration-time characteristics and deformation-time characteristics, as well as the deformation modes of the respective parts involved, agree quite well with the test results.

81-2504

Soil-Structure Interaction Methods SLAM Code. Volume 4

C.J. Costantino and C.A. Miller
Brookhaven Natl. Lab., Upton, NY, Rept. No. BNL-NUREG-51263, 150 pp (Jan 1981)
NUREG/CR-1717-V-4

Key Words: Interaction: soil-structure, Computer programs, Finite element technique

This report presents a detailed description of SLAM Code, a large finite element computer program to treat the two-dimensional (axisymmetric or planar) wave propagation problem through arbitrary nonlinear materials and the interaction of these motions with a flexible structure embedded within or on the soil.

GENERAL TOPICS

TUTORIALS AND REVIEWS

(See Nos. 2307, 2489)

USEFUL APPLICATIONS

(See No. 2394)

AUTHOR INDEX

CALENDAR

DECEMBER 1981

1-3 10th Turbomachinery Symposium [Texas A&M Univ.] Houston, TX *(Peter E. Jenkins, Director, Turbomachinery Labs., Dept. of Mech. Engrg., Texas A&M Univ., College Station, TX 77843 - (713) 845-7417)*

1-3 Automotive Plastics Durability Conference and Exposition [SAE] Troy, MI *(SAE Hqs.)*

8-10 Western Design Engineering Show [ASME] Anaheim, CA *(ASME Hqs.)*

FEBRUARY 1982

22-26 SAE Congress and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1982

29-Apr 1 Design Engineering Conference and Show [ASME] Chicago, IL *(ASME Hqs.)*

30-Apr 1 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] Oak Brook, IL *(Ronald L. Eshleman, Director, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)*

APRIL 1982

14-16 Fatigue Conference & Expositon [SAE] Dearborn, MI *(SAE Hqs.)*

18-22 Gas Turbine Conference and Products Show [ASME] London, England *(ASME Hqs.)*

20-22 Mechanical Failures Prevention Group 35th Symposium [National Bureau of Standards] Gaithersburg, MD *(Dr. James G. Early, National Bureau of Standards, Bldg. 223/Room A-113, Washington, DC 20234 - (301) 921-2976)*

20-23 Institute of Environmental Sciences' 28th Annual Technical Meeting [IES] Atlanta, GA *(IES, 940 E. Northwest Highway, Mt. Prospect, IL 60056 - (312) 255-1561)*

22-23 13th Annual Pittsburgh Conference on Modeling and Simulation [School of Engineering, Univ. of Pittsburgh] Pittsburgh, PA *(William G. Vogt or Merlin H. Mickle, Modeling and Simulation Conf., 348 Benedum Engrg. Hall, Univ. of Pittsburgh, Pittsburgh, PA 15261)*

26-30 Acoustical Society of America, Spring Meeting [ASA] Chicago, IL *(ASA Hqs.)*

MAY 1982

12-14 Pan American Congress on Productivity [SAE] Mexico City *(SAE Hqs.)*

24-26 Commuter Aircraft and Airline Operations Meeting [SAE] Savannah, GA *(SAE Hqs.)*

JUNE 1982

7-11 Passenger Car Meeting [SAE] Dearborn, MI *(SAE Hqs.)*

JULY 1982

13-15 'Environmental Engineering Today' Symposium and Exhibition [SEE] London, England *(SEE, Owles Hall, Buringford, Herefordshire, UK)*

19-21 12th Intersociety Conference on Environmental Systems [SAE] San Diego, CA *(SAE Hqs.)*

AUGUST 1982

16-19 West Coast International Meeting [SAE] San Francisco, CA *(SAE Hqs.)*

SEPTEMBER 1982

13-16 International Off-Highway Meeting & Exposition [SAE] Milwaukee, WI *(SAE Hqs.)*

OCTOBER 1982

4-6 Convergence '82 [SAE] Dearborn, MI *(SAE Hqs.)*

4-7 Symposium on Advances and Trends in Structural and Solid Mechanics [George Washington Univ. and NASA Langley Res. Ctr.] Washington, DC *(Prof. Ahmed K. Noor, Mail Stop 246, GWU-NASA Langley Res. Ctr., Hampton, VA 23665 - (804) 827-2897)*

12-15 Stapp Car Crash Conference [SAE] Ann Arbor, MI *(SAE Hqs.)*

25-28 Aerospace Congress & Exposition [SAE] Anaheim, CA *(SAE Hqs.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 5804
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - U.S. National Committee
c/o MIT Lincoln Lab.
Lexington, MA 02173

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PUBLICATION POLICY

Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .

The format and style for the list of References at the end of the article are as follows:

- each citation number as it appears in text (not in alphabetical order)
- last name of author/editor followed by initials or first name
- titles of articles within quotations, titles of books underlined
- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- volume, number or issue, and pages for journals; publisher for books
- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).

2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).

3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Devel. (1962).

4. Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).

5. Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).

6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).

7. Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).

Articles for the DIGEST will be reviewed for technical content and edited for style and format. Before an article is submitted, the topic area should be cleared with the editors of the DIGEST. Literature review topics are assigned on a first come basis. Topics should be narrow and well-defined. Articles should be 1500 to 2500 words in length. For additional information on topics and editorial policies, please contact:

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